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ORIGINAL RESEARCH ARTICLE UHD JOURNAL OF SCIENCE AND TECHNOLOGY

Exploring Knowledge and Self-Care Practice Toward Skin Aging and Sun Protection among College Students in Sulaimani City-Iraq

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ABSTRACT

Several studies have been performed internationally to assess the understanding and self-care exercise of people in the direction of sun exposure and sun protection measures, as self-care is an essential pillar of public health. Nevertheless, limited data on these factors are available from the Middle East. The aim of this study was to investigate the students' awareness of skin aging and sun-protection measures among college students. For this purpose, a cross-sectional questionnaire was specially designed; a random sample of the students in the different college of the University of Sulaimani was selected. Data were collected between January and May 2017. The relationship between the skin cancer awareness and different sociodemographic characteristics was produced by applying multiple logistic regressions. The questionnaires were distributed to 450 college students. A total of 413 questionnaires had been completely responded and covered within the data analysis, with a response rate of 91.7%. 41% of the respondents were females and 61.0% of the participants were aged between 18 and 21 years old. 47% have been privy to the association between sun exposure and skin aging. The respondents had been more likely to be aware of the connection between sun exposure and skin cancer ($P < 0.03$). The respondents from the third class of undergraduates were more likely to be familiar ($P < 0.04$). Staying under the shade during the outdoor activity was reported by more than 90% of our participants and is positioned as the most frequently used sun protection method.

Index Terms: Skin Aging, Skin Cancer, Skin Care, Sunscreen

1. INTRODUCTION

It is commonly agreed that certain people look "young for their age" or "old for their age." Moreover, the two common processes that influence skin aging are the skin aging that genetically determined and happens by passing time which is named chronologically (or intrinsic) skin aging process, while premature (or extrinsic) skin aging process is triggered by environmental factors. Recognized environmental factors that lead to premature skin aging process are sun exposure, air pollution, and smoking. The extrinsic skin aging rate is different notably among ethnic groups and individuals, whereas for the intrinsic rate of skin aging this occurrence does not relate [1]-[4].

Over the past decades, there has been a major growth in the instances of skin disease all over the world. Vital public health implications will occur when individual exposure to high cumulative levels of ultraviolet (UV) radiation [5], [6]. Unprotected and excessive sun exposure can damage skin cells, influence the normal growth of the skin and as a result cause several skin diseases such as burning and tanning. In addition, severe skin problems can occur when humans are

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exposed to large quantities of solar UV radiation, including skin aging, pigmentary changes, and skin cancer [7]-[11].

UV radiation is the most important environmental factor which leads to premature skin aging [2]. Human beings are exposed to massive portions of UV radiation in part through numerous sources which include living and traveling in sunny climates and outdoor activity, additionally due to thinning of the ozone layer within the stratosphere [5]. The harmful effect of UV radiation on the skin look regarding facial aging was previously discovered in the end 19th century by the two dermatologists Unna and Dubreuilh [12], [13]. Harry Daniell, in 1971, discovered the associations between cigarette smoking and skin aging [14]. Moreover, moderate alcohol consumption has also been shown to correlate with skin appearance [15]. Recent observation reported that air pollution is another significant environmental factor, which influences the skin appearance and leads to skin aging intrinsically [16]. Skin cancer has increased gradually during the past 50 years. Epidemiological studies demonstrate that skin cancer is developed by the sun, which is considered as the main considerable environmental factor which influences the skin. To reduce the skin cancer occurrence, the first step needs to be done increasing levels of awareness and self-care knowledge of the sun's harmful effects and how to better protect from solar emission [5], [17], [18]. It is essentially important to focus on educational level; this is with the purpose of changing behavioral patterns and protecting people against the dangerous effects of the sun [17]. Education plays a key role in raising awareness [19], [20]. Several types of research have been studied in different countries to determine people knowledge levels about the sun effect on facial aging and awareness level concerning sun protection [21].

In local skin care hospital, we have observed that many patients do not protect themselves from the sun and report unhealthy attitudes toward this subject. Exploring deficits in sun protection awareness and self-care practice toward different environmental factors can serve as a starting point for primary prevention interventions. Identifying knowledge and self-care practices of the public regarding skin aging, exposure and protection of the sun have been studied in several countries. Nevertheless, there is no study regarding this issue in Sulaimani city-Iraq. The purpose of the following study is to find out the levels of knowledge and self-care practice in regard to skin aging, sun exposure, and protection among college students. In addition, we will present the student's knowledge about various environmental factors such as air pollution, smoking, and drinking alcohol on skin aging.

2. MATERIALS AND METHODS

A cross-sectional survey was carried out between January 2017 and May 2017, both males and females students were involved at different colleges of Sulaimani University. From each college, several departments were selected randomly. A total of 413 questionnaires were collected. Data collection was performed by several trained students. The data collection process in this study was carried out using the questionnaire, which was specially created throughout a search of appropriate literature [1], [5], [7]. The re-designed questionnaire was tested initially in Sulaimani Center for Dermatology and Venereal Disease-Teaching Hospital to estimate approximately the length of the questionnaire in minutes, verify the participant's interpretation of questions and develop the questionnaire consequently. These questionnaires were tested in independent data sets, but these candidate questionnaires were excluded from the concluding analysis. However, the final version of the survey was conducted in the University of Sulaimani. The final version of the questionnaire included 24 questions and required approximately 5 minutes to complete. Approval from the Ethics Committee of University of Sulaimani, Sulaimani, Iraq, was obtained. The self-administered questionnaire was composed of three sections. The first section of the questionnaire comprised nine questions about personal information, such as university level, residence (urban vs. rural), gender, age, marital status, weight, high, smoking, and drinking alcohol. Various questions were integrated into the second part of the questionnaire about the student's knowledge concerning the factor of skin aging, sun's benefits and harmful effects on the skin and use of sun protection methods. The data were analyzed using Statistical Package for the Social Sciences Program (SPSS) version 21. After that the statistical assessment of data and the summarization of frequencies and percentages, multiple logistic regressions were used. Statistical significance was defined as $P < 0.05$.

3.RESULTS

The questionnaire was distributed to 453. A complete data from 413 participants were returned and integrated into the analysis with a 91.7% response rate. There was a various range of age of the students who participated in the survey, 61.0% (252/413) of the respondents were aged 18-21 years old, while, and 34.1% (141/413) of the students were aged between 22 and 25. Only 4.8% (20/413) of the participants were aged over 25 years. In addition, 58.6% (242/413) of the students who contributed to the survey were male,

while 41.4% (171/413) of the participants were female. The sociodemographic characters of the research population are depicted in Table I.

The level of awareness among students regarding unprotected exposure to the sun caused skin damage is illustrated in Table II. This study has indicated that the majority of respondents were mindful that excessive sun exposure causes skin burn (87.9%, 363/409). 47% (194/402) reported that sun exposure can cause skin aging, while almost more than a half of respondents (52.5%, 217/404) were responsive of the relationship between skin cancer and sun exposure. Nevertheless, the level of knowledge of students regarding the impact of sunlight on skin was explored; understanding of the relationship between synthesis of Vitamin D and sun exposure was the most well-known benefit of the students, with 76.1% of the male and 70.7% of the female citing it. The male and female participants were reported (74.4% and 70.6%, respectively) regarding the association between sun exposure and treatment in some skin conditions. The relationship between positive psychological effects sun exposure was recorded 63% in male respondents, while only 37.0% of the female participants were aware of this relation, as shown in Table III.

TABLE I
Sociodemographic data of the 413 participants

Characteristics	Count (%)[a]
Gender	
Male	242 (58.6)
Females	171 (41.4)
Age (years)	
18-21	252 (61.0)
22-25	141 (34.1)
Over 25	20 (4.8)
Marital status	
Single	377 (91.3)
Married	32 (7.7)
Residence	
Urban	249 (60.3)
Rural	162 (39.2)
Education (undergraduate)	
Class 1	137 (33.2)
Class 2	113 (27.4)
Class 3	65 (15.7)
Class 4	85 (20.6)

[a]The denominator is different among variables due to missing values

TABLE II
Awareness of negative effects of the sunlight among respondents

	n (%)[a]		
	Yes	No	Don't know
What damage does excessive sun-exposure cause?			
Skin burn	363 (87.9)	18 (4.4)	28 (6.8)
Skin aging	194 (47.0)	74 (17.9)	134 (32.4)
Skin cancer	217 (52.5)	62 (15.0)	125 (30.3)

[a]The denominator is different among variables due to missing values

The logistic regression models were used to assess the relationship between the demographic factors influencing awareness of the connection between sun exposure, and skin cancer is shown in Table IV.

Students aged 18-21 years reported higher rates of skin cancer knowledge ($P < 0.025$). Similarly, respondents from Class 3 were more likely to be linked with the understanding of the association between sun exposure and skin cancer ($P < 0.037$). However, there was no significant dissimilarity found in awareness between students rooted in their gender, marital status, or area of residence (rural vs. urban).

The sun protection behaviors among respondents are summarized in Table V. 56% of study students reported that they were protecting themselves during the daytime against the effects of the sun by wearing sun protection cream (232/401), wearing sunglasses (61.9%, 256/401), and light-colored cotton clothes (83.1%, 343/407). Wearing "a hat" was found to be the least frequently used the technique of sun protection (40.2%, 166/391). The preferred method of protection during their outdoor activities was staying in the shade and inside with the data (90.6%, 374/406) (87.9%, 363/404), respectively. In addition, 87.9% (363/404) of participants reported that they were trying to stay inside to protect their skin from the sunlight. Data on using anti-aging

TABLE III
Students' levels of knowledge about beneficial effects of the sunlight

Factor	Male, *n* (%)		Female, *n* (%)	
	Yes	No	Yes	No
Synthesis of Vitamin D	181 (76.1)	57 (23.9)	118 (70.7)	49 (29.3)
Treatment in some skin conditions	177 (74.4)	61 (25.6)	115 (70.6)	48 (29.4)
Positive psychological effects	133 (63.0)	104 (56.5)	78 (37.0)	80 (43.5)

skin product among our respondents showed that just about 55% of the female students reported that they never used anti-aging cream. Of respondents, only 45.1% (60/133) and 31.1% (60/183) of the female and male, respectively, had ever used sunscreen anti-aging product.

In addition, the students were asked about the importance of looking after their skin. As illustrated in Fig. 1, a surprising result had been recorded in this section, most of the students reported that it is important to look after their skin.

In this study, the participants were asked about their concern for various issues relating to the premature skin aging such. According to the data, stress was the most concerned respond, and the majority of students were submitted their choice to less concerned about sun exposure as shown in Table VI.

Perceptions of key factors of aging among students were recorded, and poor diet was considered as the main factor of aging among the students (33.1%) as shown in Table VII.

TABLE IV
Logistic regression analyses of skin cancer awareness and sociodemographic characteristics

	P value	Odds ratio 95% CI (lower bound-upper bound)
Male	0.082	0.624 (0.367-1.061)
Age 18–21 years	0.025	5.992 (1.255-28.603)
Single	0.196	0.514 (0.188-1.410)
Urban	0.268	1.333 (0.802-2.217)
Class 3	0.037	0.427 (0.192-0.949)

CI: Confidence interval

TABLE V
Respondents applied sun protection methods

	n (%) [a]		
	Regularly	Never	Sometimes
Which of the protection methods do you often use during the daytime?			
Wear sun protection cream	81 (19.6)	169 (40.9)	151 (36.6)
Wear hat	24 (5.8)	225 (54.5)	142 (34.4)
Wear sunglasses	89 (21.5)	14 (35.1)	167 (40.4)
Wear light cotton clothes	92 (22.3)	64 (15.5)	251 (60.8)
Stay under shade	137 (33.2)	32 (7.7)	237 (57.4)
Stay inside	113 (27.4)	41 (9.9)	250 (60.5)

[a]The denominator is different among variables due to missing responses

4. DISCUSSION

Information about public knowledge and behaviors regarding skin aging and protection measures among Kurdish people are little, and none official study in Kurdistan was found after a broad literature review on this topic. Diverse climate conditions can be found in different regions of Iraq. The Northern part of Iraq, which is called Kurdistan, has a cooler atmosphere than the southern part. The climate of Kurdistan has distinct high temperatures in day-time and low temperatures during the nighttime. From June to September, daytime temperatures reach 44°C or higher throughout the area. The south has higher temperatures, which can go as high as 48°C during summer time. In our local clinical dermatology center, we noticed that various sun's related skin diseases such as sunburn are more common in the summer period because the weather in the summer is exceptionally hot.

There has been an important increase in the incidence of the skin cancer over the past few decades. In addition, it has been shown that developing this condition is related to over a lifetime commutation of sun exposure [22].

It has been reported that with the implementation of sun protection measures and proper behaviors approximately around 80% of skin cancer cases can be prevented. Nevertheless, the occurrence of skin cancer is still increasing [23]. This study has indicated that more than 90% of our study respondents they commonly stayed under the shade to avoid the harmful effects of sun exposure. Gray *et al.* and Ergin *et al.* achieved a similar result in their 2012

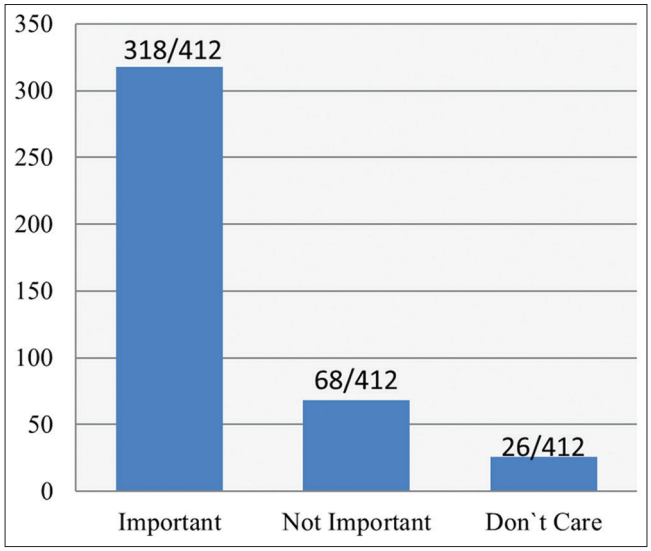

Fig. 1. How Important is to look after the skin?

TABLE VI
Participants concern about issues relating to skincare

	n (%)		
	Concerned	Not concerned	Missing-value
Premature aging caused by			
Sun exposure	248 (60.0)	159 (38.5)	6 (1.5)
Stress	347 (84.0)	63 (15.3)	3 (0.7)
Lack of sleep	303 (73.4)	106 (25.7)	4 (1.0)
Smoking	339 (82.1)	70 (16.9)	4 (1.0)
Drinking alcohol	299 (72.4)	108 (26.2)	6 (1.5)

TABLE VII
Key factors of skin aging

Main factor of aging[a]	Responses *n* (%)	Percent of cases (%)
Sun	97 (14.9)	24.3
Weather	156 (24.0)	39.1
Pollution	181 (27.9)	45.4
Poor diet	215 (33.1)	53.9
Total	649 (100.0)	162.7

[a]Dichotomy group tabulated at value 1

and 2011 study, respectively [5], [24]. Despite the fact that, Kokturk *et al.* and Kaymak *et al.* found that staying inside at peak times to be the most commonly practiced method of avoiding the harmful effects of the sun, with 53% and around 45% for women and men [18], [25]. Approximately 52% of the respondents reported awareness of the link between sun exposure and the hazard of skin cancer, which is comparable to the previous study carried out in Saudi Arabia by AlGhamdi *et al.* and Al Robaee [7], [26]. However, this level of awareness is considered to be lower than similar studies conducted in the western community. For instance, the relationship between sun exposure and skin cancer was made by study participants in Malta with figures of 92.5%, 92% in the United States, 90% in Australia, and 85% in Canada [27]. The outcome of this study has shown that around 88% of study participants were familiar with the linkage between the sun and skin burn. Furthermore, knowledge of respondents about the connection between sun exposure and skin aging was confirmed with 47%. In this study, the participants were questioned about their levels of knowledge of the benefits of the sunlight; slight gender distinction was noted in answer to the positive effect of the sun on the synthesis of Vitamin D and treatment in several skin conditions. It was found that 76.1% of the male was aware of the positive effect of the synthesis of Vitamin D in comparison to 70.7% of the female. In addition, the results of well-known effects of treatment in some skin conditions were analyzed; these statistics were 74.4% for male and 70.6% for female.

Regardless of the reasonably superior information and awareness among our study participants that the sunlight predisposes people to several skin disorders, including skin aging, sunburn, and skin cancer, the rate of sunscreen attentiveness was low. This study reported that more than half of the participants wear sun protection cream. In addition, 40.9% of the respondents reported that they have never used sunscreen. The finding regarding the use of sunscreen has been cited by several studies on this subject matter [26], [28], [29]. Moreover, around 62% of students stated that they wear sunglasses as one of the sun protection methods. Nikolaou *et al.* reported that in Mediterranean population sunglasses was the most regularly used sun protection with the number of 83.4% [30]. As we have shown, protective clothes were used as sun protection among students, as 83.1% of respondents reported wearing light cotton clothes, and 40.2% of them reported using a hat during outdoor activities. Certainly, this rate of sun protection utilizes and knowledge among the Kurdish people as reported by this study is quite alarming and should spotlight the interest in this concern with regard to health education programs and future studies. Additional learning is needed as the knowledge only is not sufficient to make a transform in approach. Universities are ideal environment because of their existing infrastructure to help students attaining the essential healthy behaviors. Sun protection awareness and ideas can be integrated into the existing areas of study programs.

Nevertheless, this study has several potential limitations that should be reserved when interpreting the results. An expediency sample of students from only one university was surveyed. Therefore, caution must be kept in mind in expanding our findings to other universities, especially universities situated in other geographical regions. Another limitation to these findings is the reality that the students were asked to report their answers as yes or no with offered statements about sun exposure harmful effect including skin aging, skin burn, and skin cancer, which may prejudice responses and direct to a mistaken evaluation of the proportion of the public who have true and factual information of the sun side effects. Finally, the results of this study limited by cross-sectional character, which means that commands of effects can only be hypothesized.

5. CONCLUSION AND RECOMMENDATION

This study has specified a low level of public knowledge and self-care practice among the college students regarding skin aging, the harmful effects of sun exposure and sun protection methods. In addition, this study has discovered that sun protection measure is commonly inadequate among students and on a regular basis only a small part of participants uses sunscreen. Therefore, this research highlights the requirement for the media, further studies and future well-being education programs to be utilized with the purpose of developing the implementation of sun protection behaviors including wearing sunscreen regularly and wearing protective clothes among the general public.

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ORIGINAL RESEARCH ARTICLE UHD JOURNAL OF SCIENCE AND TECHNOLOGY

Development Permeability prediction for Bai Hassan Cretaceous Carbonate Reservoir

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ABSTRACT

Permeability and porosity are the most difficult parameters to estimate in the oil reservoir because they are varying significantly over the reservoir, especially in the carbonate formation. Porosity and permeability can only be sampled at the well location. However, porosity is easy to estimate directly from well log data, permeability is not. In addition, permeability measurements from core samples are very expensive. Carbonate reservoirs are very difficult to characterize because of their tendency to be tight and heterogeneous due to deposition and diagenetic processes. Therefore, many engineers and geologists try to establish methods to get the best characterization for the carbonate reservoir. In this study, available routine core data from three wells are used to develop permeability model based on hydraulic flow unit method (HFUM) (RQI/FZI) for cretaceous carbonate middle reservoirs of Bai Hassan oil field. The results show that the HFUM is work perfectly to characterize and predict permeability for uncored wells because $R^2 \geq 0.9$. It is indicating that permeability can be accurately predicted from porosity if rock type is known.

Index Terms: Carbonate Reservoir, Core Data, Dykstra-Parsons Coefficient (VK), Hydraulic Flow Unit Method (RQI/FZI), Permeability, Porosity, Winland Method

1. INTRODUCTION

Permeability is one of the most important and critical petrophysical properties to determine the economic value of a reservoir. Prediction of permeability serves as a platform and prerequisite for any integrated reservoir studies. Single-phase permeability measurements are important to understand fluid flow through porous media. Permeability can be estimated indirectly using log data directly with core sample. Engineers and geologists observed that there is not a specifically defined trend line between porosity and permeability. In addition, their relationship is qualitative and is not direct or indirect in any way because it is possible to be high porosity without permeability as in clay and shale, Qays [1]. In addition, it is true to be high permeability with low porosity as in microfractured carbonates. However, there often can be found a very useful correlation between them, Tiab and Donaldson [2].

Kozeny [3] proposed the first empirical equation relating measurable rock properties with permeability using bundle of straight capillary tubes model with constant and uniform surface area. Carman [4] modified Kozeny equation by describing permeability in packs of uniformly sized spheres. Timur [5] proposed a generalized equation based on the work of Kozeny [3].

Amaefule *et al.* [6] introduced a new practically and theoretically based technique, which has been developed to identify and characterize units with similar pore throat geometrical attributes (hydraulic units). This theory of

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hydraulic flow units (HFUs) and reservoir quality index pending the pore-throat, pore and grain arrangement and different macroscopic parameters.

2. FIELD DESCRIPTION

Bai Hassan field (Fig. 1) is located in the north of Iraq to the northwest of Kirkuk governorate and to the north of Kirkuk giant oil field. It is elongated from the north-west to the south-east; the surface structure differs from the subsurface structures because of the faults effect. The field is of a very complex nature with several main opposite faults and mini faults spreading in the field. It is 40 km in length and 3.8 km in width, it was discovered in 1929 and the production started on 1959, Sadeq [7].

3. DYKSTRA-PARSONS COEFFICIENT VK

Dykstra and Parsons used the log-normal distribution of permeability to define the coefficient of permeability variation, Tiab and Donaldson [2].

$$V_k = \frac{S}{K} \tag{1}$$

$$K = \sqrt{\frac{\sum (K_i - K^-)^2}{n}} \tag{2}$$

S is the standard deviation for permeability, n is a number of samples, K and K^- are the permeability, and mean *Ki* is the permeability of main direction.

The range of this index is $0<V_K<1$ as and can be interpreted as follows:

1. If $V_K=0$, the reservoir is ideal homogeneous
2. If $0<V_K<0.25$, then the reservoir is slightly heterogeneous
3. If $0.25<V_K<0.50$, the reservoir is heterogeneous
4. If $0.50<V_K<0.75$, the reservoir is very heterogeneous
5. If $0.75<V_K<1$, the reservoir is extremely heterogeneous, and
6. If $V_K = 1$, then the reservoir is perfectly heterogeneous, Tiab and Donaldson [2].

Hence, for Bai Hassan cretaceous middle carbonate reservoir, V_K = 11.4/12.59 = 0.9. This value of Dykstra-Parsons coefficient shows that the reservoir is extremely heterogeneous because it is a fractured carbonate reservoir.

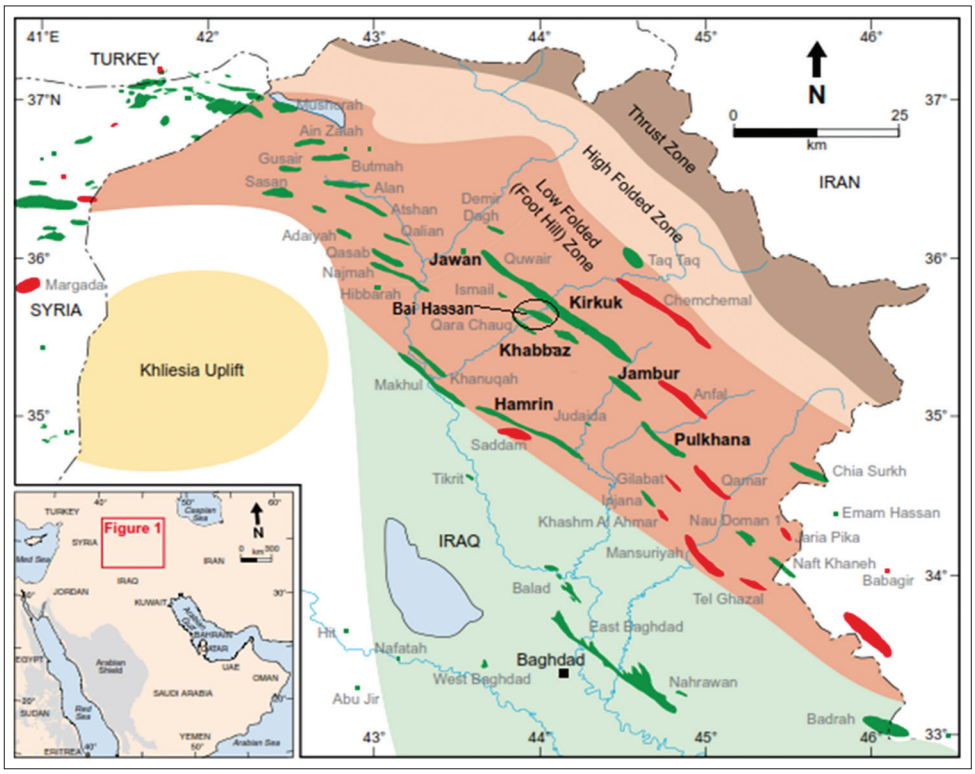

Fig. 1. The location of studied Bai Hassan field, Sadeq and Bhattacharya [8].

4. PERMEABILITY PREDICTION DEPENDING ON ROCK TYPE METHODS

A. Conventional Method

Conventional method for rock typing is based on simple regression evaluating permeability from log-derived porosity. In most cases, a linear relationship between log permeability and porosity is obtained, but in carbonate formations, it does not close to the actual case. Fig. 2 shows the conventional permeability-porosity relationship for the entire reservoir. There is a poor relationship between permeability and porosity ($R^2 = 0.191$).

B. Winland Method

In this approach, a mathematical relationship introduced between the petrophysical properties such as porosity, permeability, and capillary pressure to pore-throat radius measured in a mercury injection capillary pressure experiment at mercury saturation of 35%, Gunter *et al.* [9]. The Winland equation is:

$$\log(R_{35}) = 0.732 + 0.588\log(k) - 0.864\log(\varnothing) \quad (3)$$

Where, R_{35} is the calculated pore-throat radius at 35% mercury saturation from mercury injection capillary pressure test, k is permeability (md), and Ø is porosity (percentage). The core samples of similar R_{35} values represent a single rock type. Petrophysical units can be defined using below classification of R_{35} values:-

1. Megaport: When the value of R35 is >10 μ
2. Macroport: When the value of R35 is between 2 and 10 μ
3. Mesoport: When the value of R35 is between 0.5 and 2 μ
4. Microport: When the value of R35 is between 0.1 and 0.5 μ.

Figs. 3-5 show the conventional permeability-porosity relationship for well A, well B, and well C depending on Winland method. As shown in these figures, there are weak relationships between permeability and porosity ($R^2 \leq 0.19$). Winland method is experimental measurements, which means that it does not work for all circumstances.

The inverse (negative) relationship between the porosity and permeability in this well resulted from the high shale volume (Vsh).

5. HFU METHOD (HFUM)

Geologists and engineers specified the definition of units to shape the description of reservoir zones as storage containers and reservoir conduits for fluid flow. Literatures confirmed

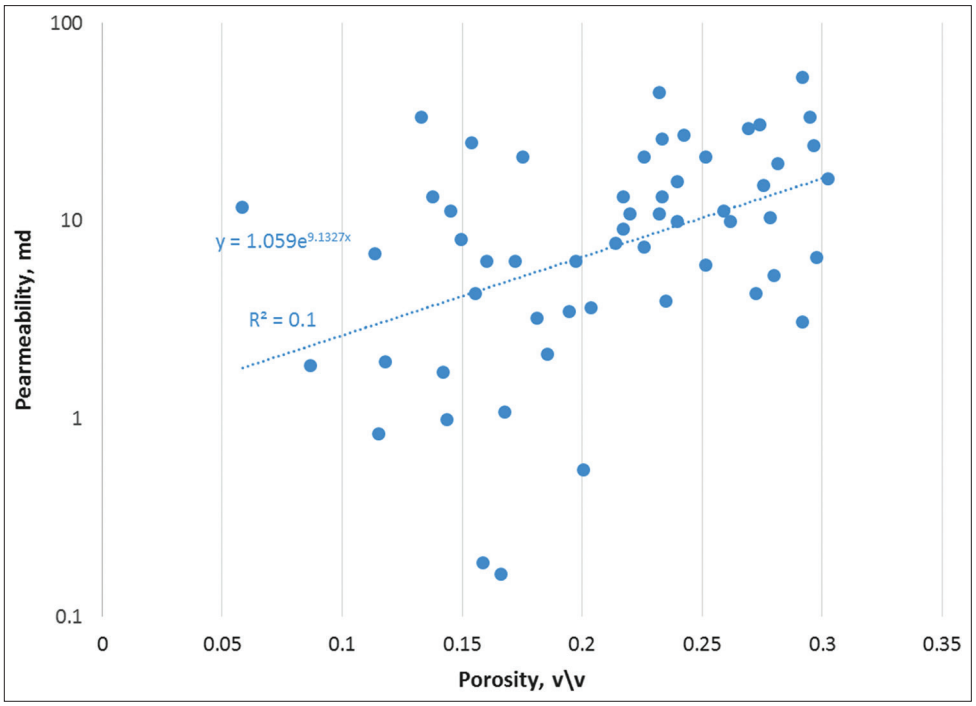

Fig. 2. Permeability porosity cross-plot for the entire reservoir

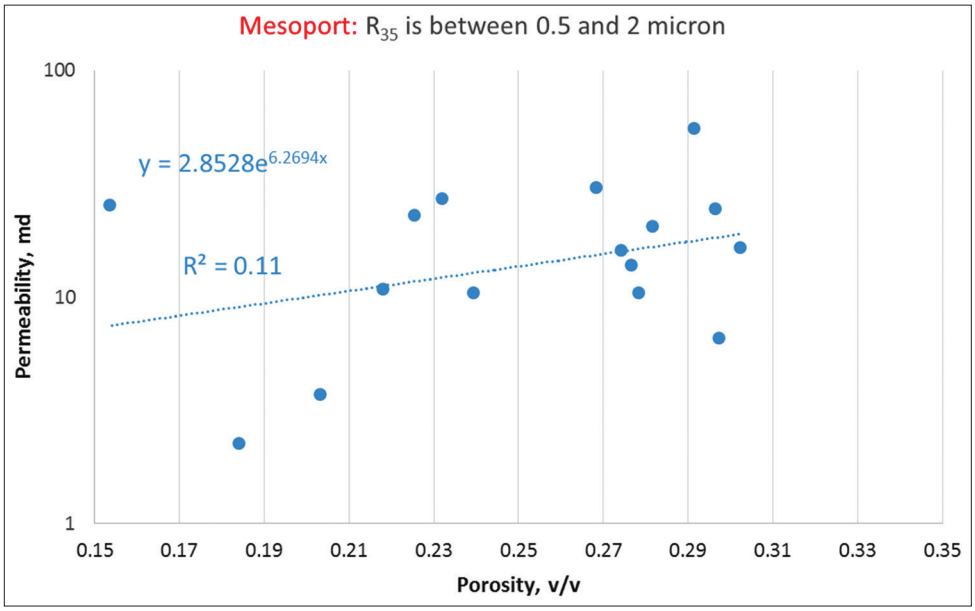

Fig. 3. Winland plot between porosity and permeability for well A

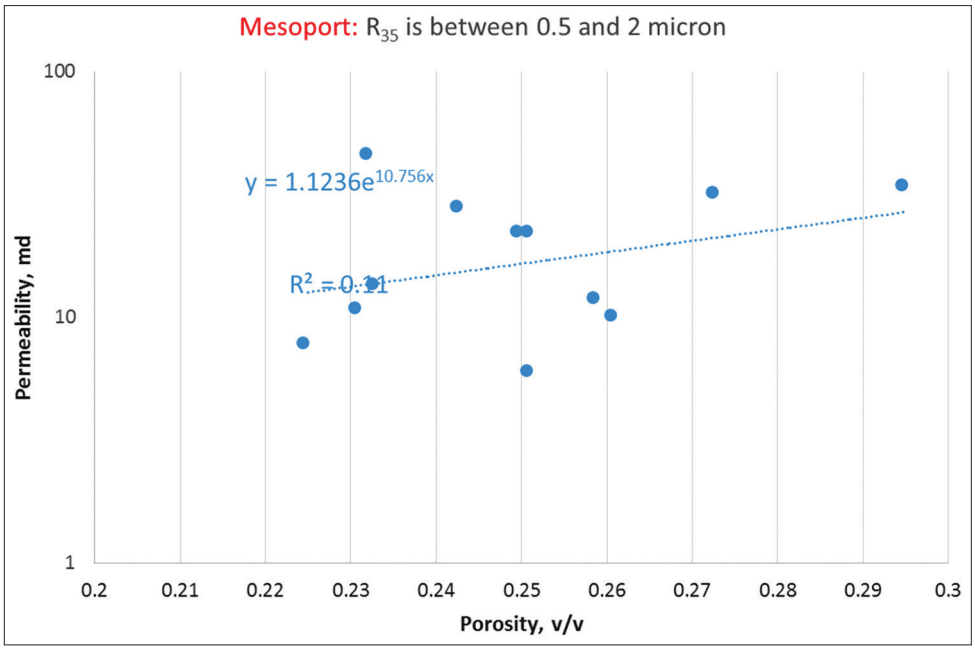

Fig. 4. Winland plot between porosity and permeability for well B

that the flow units, as the resultant of the depositional environment and diagenetic process. The hydraulic (pore geometrical) unit is the representative elementary volume of the total reservoir rock within the geological and petrophysical properties of the rock volume, Bear [10].

HFUs consider as map-able portion of the reservoir within which the geological and petrophysical properties that affect the flow of fluid are consistent and predictably different from the properties of other reservoir rock volume, Ebanks Jr. [11].

Hearn *et al.* [12] defined flow unit as a reservoir zone that is laterally and vertically has similar permeability, porosity, and bedding characteristic. A continuous stratigraphically interval of similar reservoir processes that honor the geologic framework and maintains the characteristic of the rock type, Gunter *et al.* [9]. The rock types are classified according to the following equations:

$$\log(R_{35}) = 0.732 + 0.588\log(k) - 0.864\log(\varnothing) \quad (4)$$

$$\log(R_{35}) = 0.732 + 0.588\log(k) - 0.864\log(\varnothing) \quad (5)$$

$$FZI = \frac{QRI}{\varnothing_z} \quad (6)$$

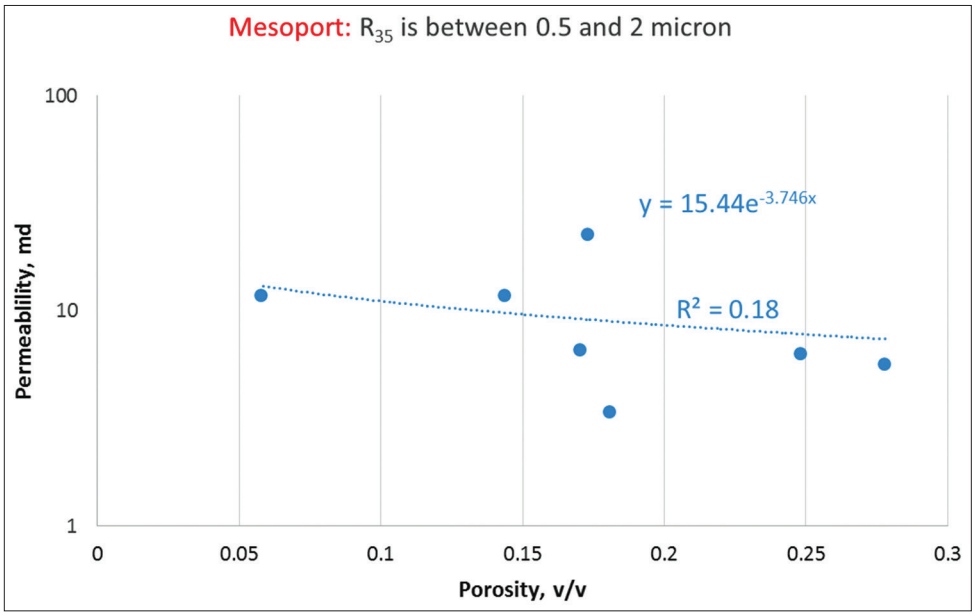

Fig. 5. Winland plot between porosity and permeability for well C

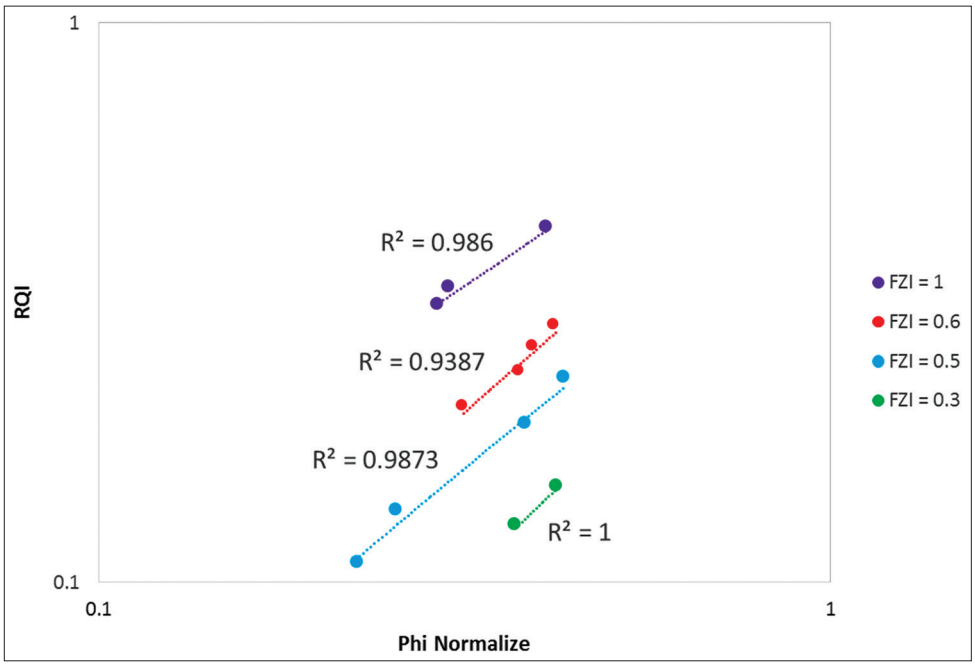

Fig. 6. Log-log plot of RQI versus Øz indicating the presence of four flow units for well A

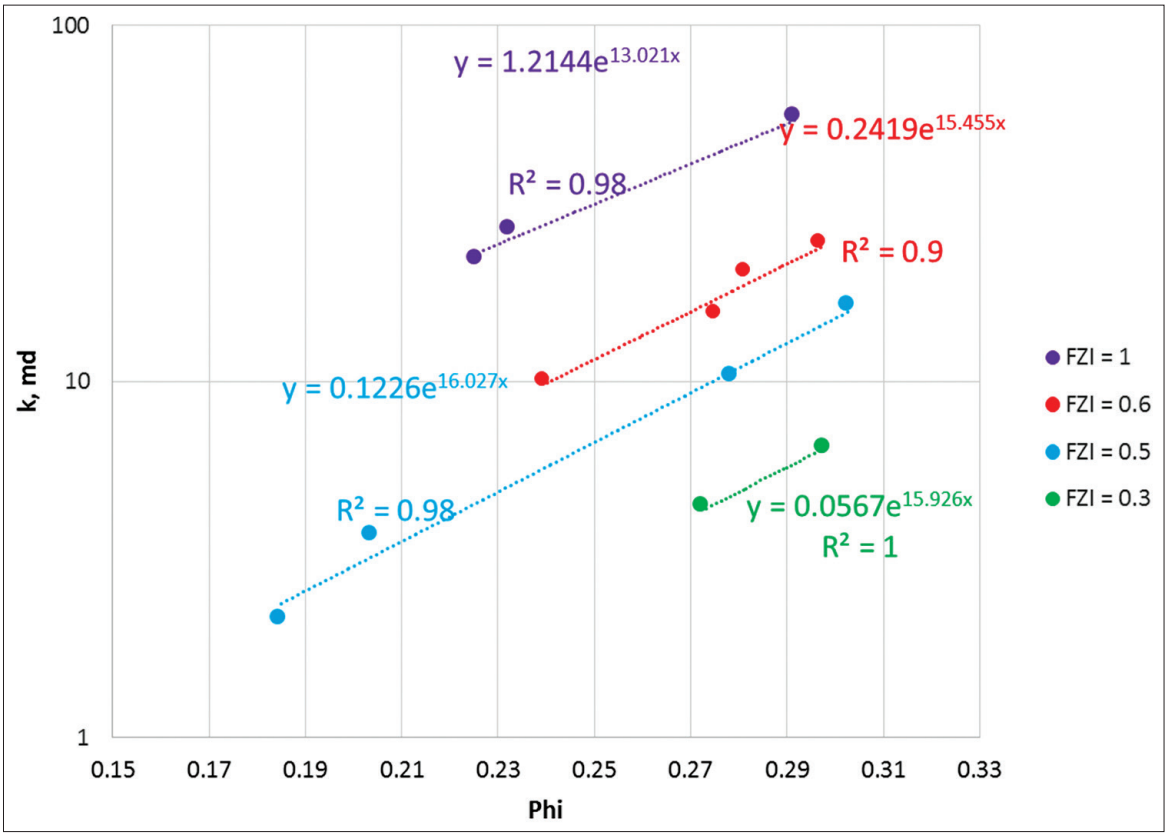

Fig. 7. Permeability porosity cross-plot for well A depending on FZI

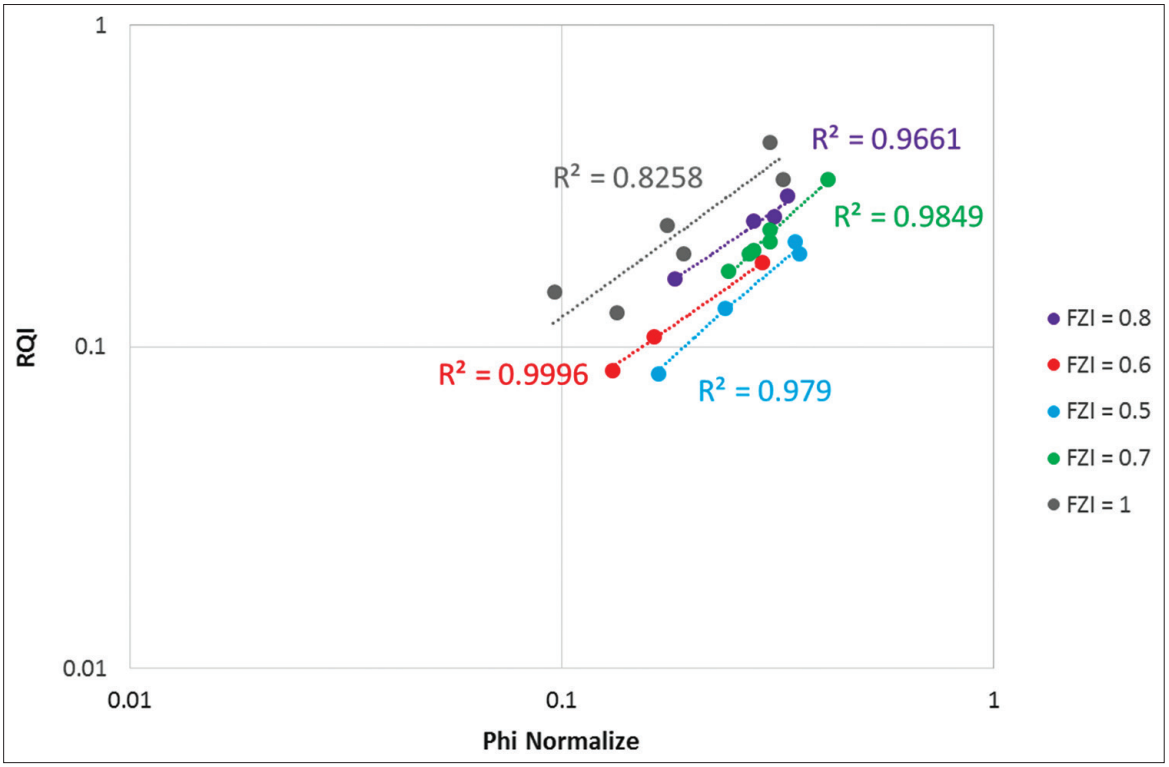

Fig. 8. Log-log plot of RQI versus Øz indicating the presence of five flow units for well B

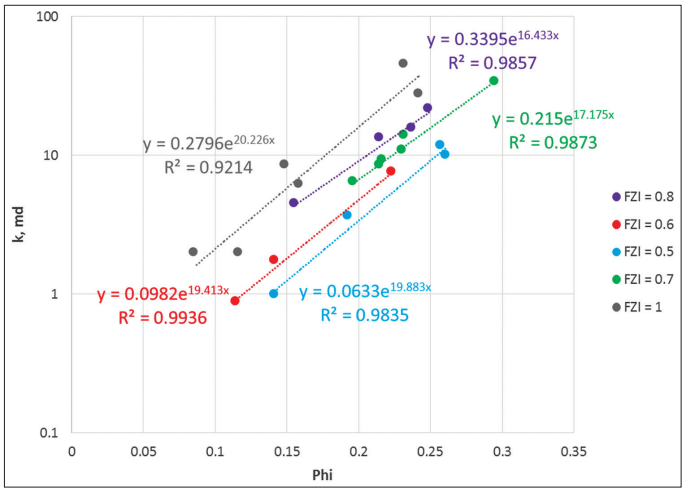

Fig. 9. Permeability porosity cross-plot for well B depending on FZI

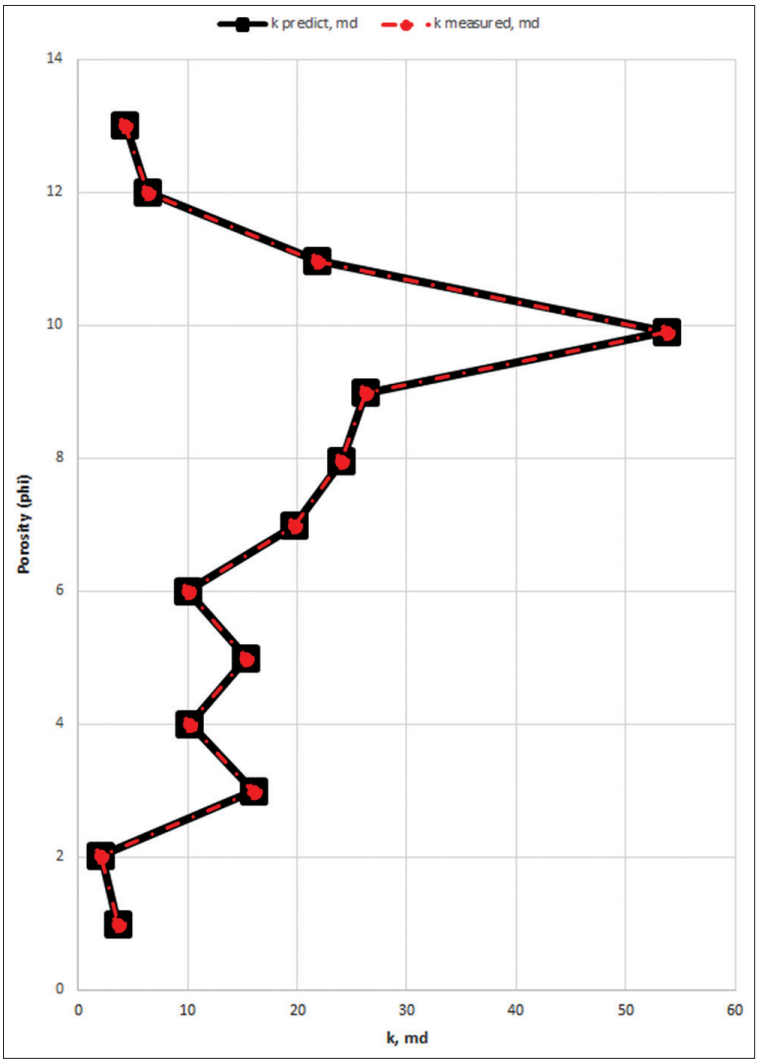

Fig. 10. Comparison between measured permeability and predicted permeability depending on Eq. (7) for well A shows excellent matching between a measured and predicted values, this represents that V_K value is very close to zero, the reservoir is ideal homogeneous

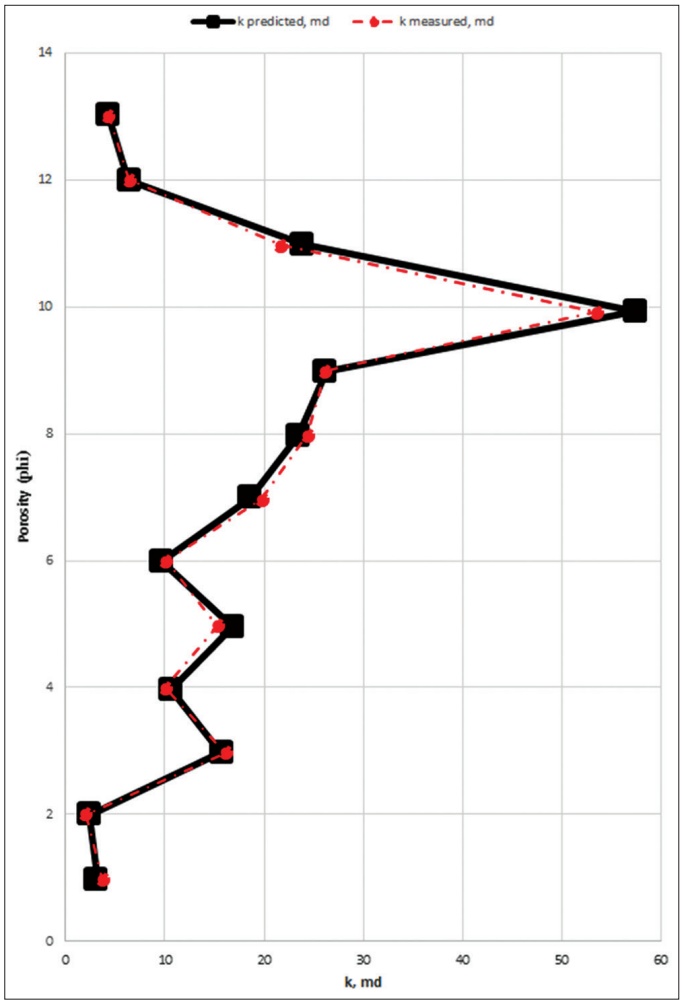

Fig. 11. Comparison between measured permeability and predicted permeability depending on k versus phi-dependent FZI for well A

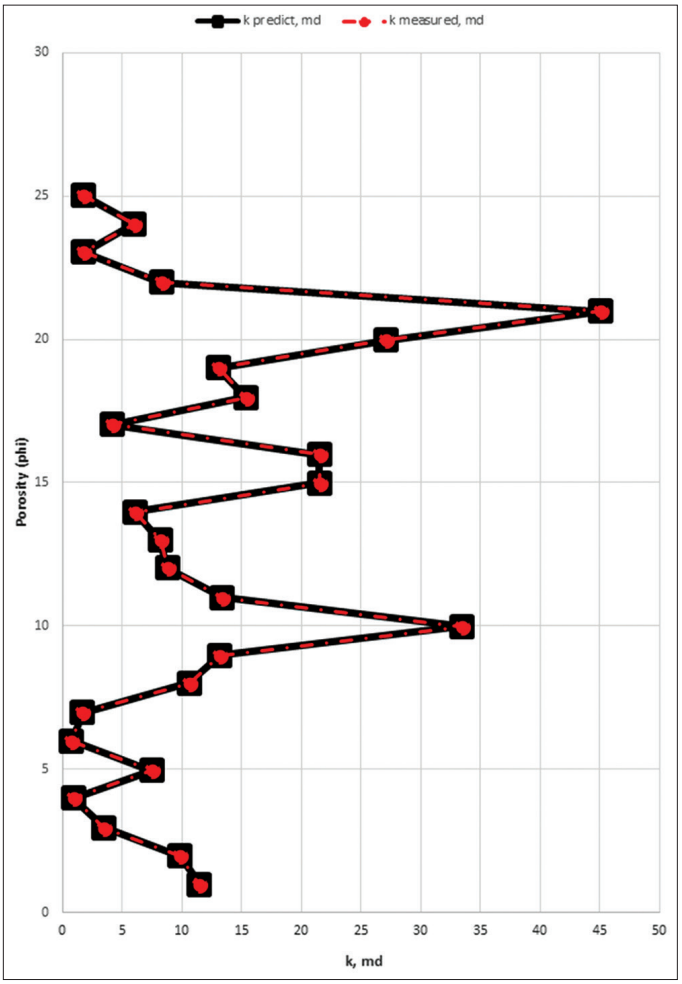

Fig. 12. Comparison between measured permeability and predicted permeability depending on Eq. (7) for well B shows excellent matching between a measured and predicted values, this represents that V_K value is very close to zero, the reservoir is ideal homogeneous

$$k = 1014\left(FZI\right)^2 \frac{\emptyset_e^{\,3}}{\left(1-\emptyset_e\right)^2} \qquad (7)$$

Where, k is the permeability (md), $\emptyset e$ is the effective porosity (fraction), RQI is rock quality index (μm), $\emptyset z$ is the normalize porosity, and FZI is flow zone indicator. On a log-log plot of RQI versus $\emptyset z$, all samples with similar FZI values will lie on other parallel lines. The values of FZI constant can be determined from the intercept of unit slope straight line at $\emptyset z = 1$, Haghighi *et al.* [13].

6. CONCLUSION

HFUM works perfectly to characterize and predict permeability for uncored wells as shown in Figs. 6, 8, and 14. They indicate that permeability can be accurately predicted from porosity if the rock type is known.

Porosity alone is not sufficient to describe the permeability variations, even if the porosity-permeability data that were used came from same field. This study shows good relationship between porosity and permeability depending on ZI as shown in Figs. 7-15.

The relationship is excellent because $R^2 \approx 1$ and the presence of good matching between measured permeability and predicted permeability as shown in Figs. 11 and 13. The observations from this study refer to insignificant differences between porosity and permeability equations for each well alone and generalize equations (all three wells

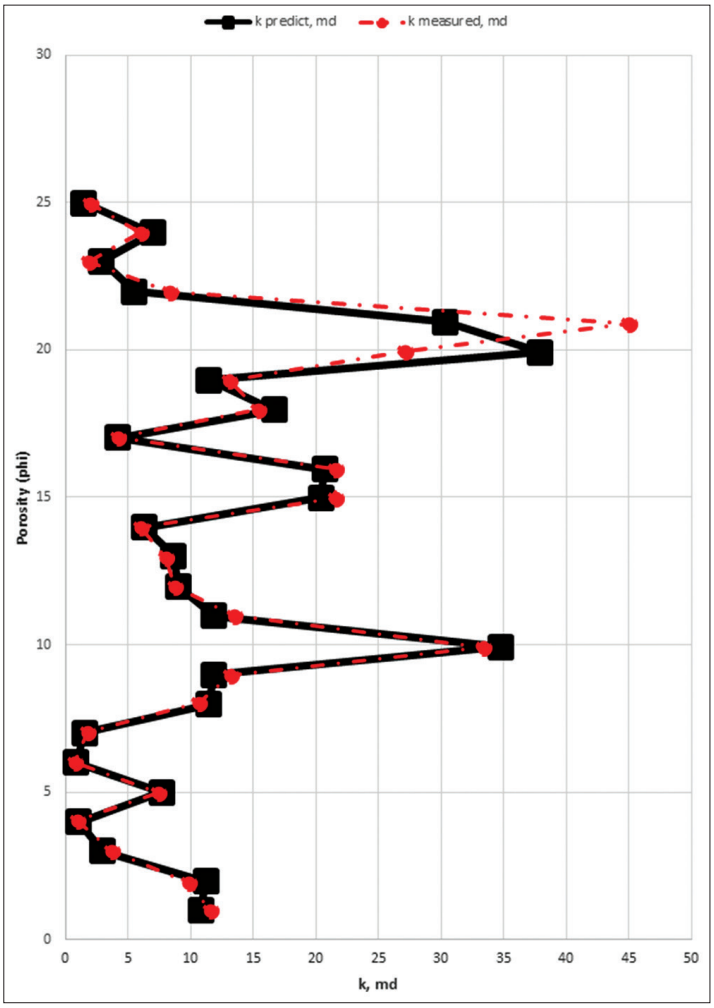

Fig. 13. Comparison between measured permeability and predicted permeability depending on k versus phi-dependent FZI for well B

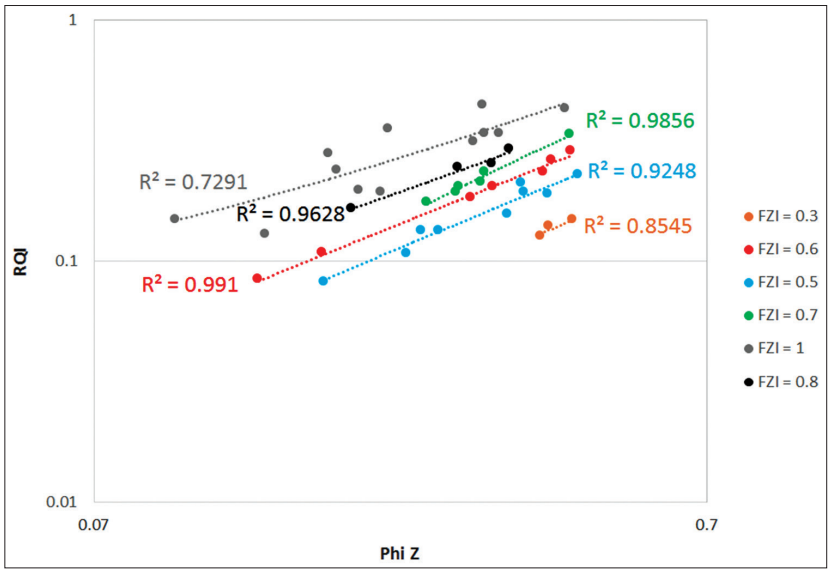

Fig. 14. Log-log plot of RQI versus Øz for the three studied wells

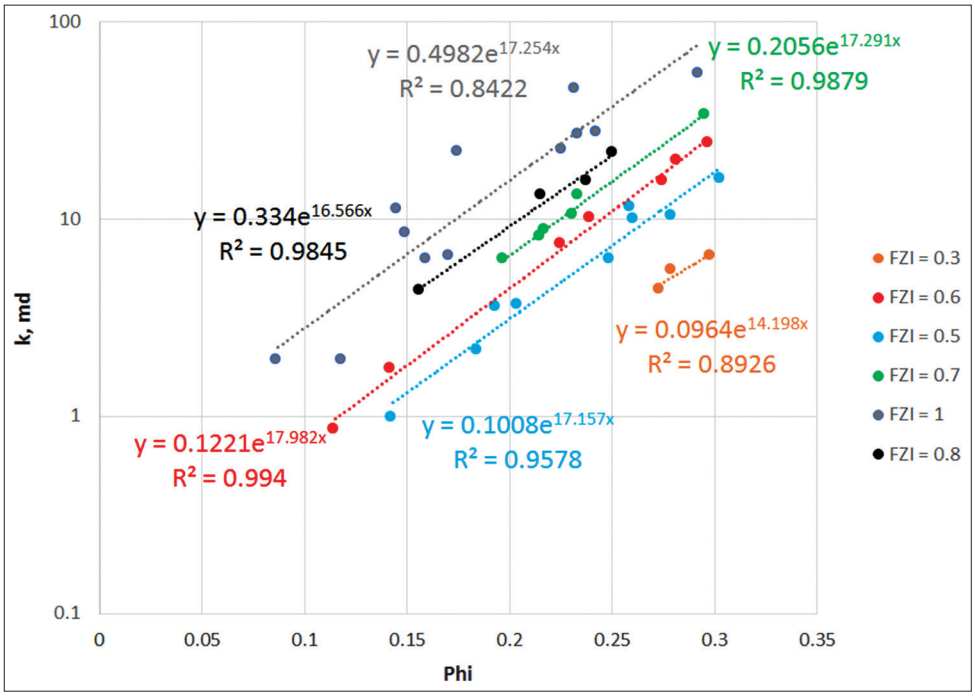

Fig. 15. Permeability porosity cross-plot for the three studied wells depending on FZI

TABLE I
Generalized permeability depending on FZI

Well No	FZI	Permeability Predicted from Equations	R^2
A	0.3	$k=0.0567e^{15.926Ø}$	1
A	0.5	$k=0.1226e^{16.027Ø}$	0.9891
A	0.6	$k=0.2419e^{15.455Ø}$	0.971
A	1	$k=1.2144e^{13.021Ø}$	0.9869
B	0.5	$k=0.0633e^{19.883Ø}$	0.9835
B	0.6	$k=0.0982e^{19.413Ø}$	0.9936
B	0.7	$k=0.215e^{17.175Ø}$	0.9873
B	0.8	$k=0.3395e^{16.433Ø}$	0.9857
B	1	$k=0.2796e^{20.226Ø}$	0.9214
A, B, and C	0.3	$k=0.0964e^{14.198 Ø}$	0.8926
A, B, and C	0.5	$k=0.1008e^{17.157Ø}$	0.9578
A, B, and C	0.6	$k=0.1221e^{17.982Ø}$	0.994
A, B, and C	0.7	$k=0.2056e^{17.291Ø}$	0.9879
A, B, and C	0.8	$k=0.334e^{16.566Ø}$	0.9845
A, B, and C	1	$k=0.4982e^{17.254Ø}$	0.8422

data). As shown in Table I, the high FZI values indicate high permeability values within four HFUs for well A and five for well B.

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ORIGINAL RESEARCH ARTICLE UHD JOURNAL OF SCIENCE AND TECHNOLOGY

Future Aspects of Intelligent Car Parking Based on Internet of Things

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ABSTRACT

Nowadays, the crowded of cars leads to big challenges in many crowded cities. This leads to environmental pollution in addition to fuel consuming. In addition, it is very important to adapt all devices, vehicles, and objects to the environment of the internet of things (IoT). In this case, it is difficult to find the nearest and shortest suitable path for car parking place. This approach aims to minimize the time for finding the car parking as well as reducing the traffic congestion. The implemented approaches try to support the driver to find near suitable car parking. The implemented approach based on intelligent aspects to achieve the performance of car parking with the future environment of IoT. Localizing of the nearest car parking is an important issue in the future IoT.

Index Terms: Car Parking, Intelligent Algorithm, Internet of Things, Real Time System

1. INTRODUCTION

More than 20 years ago, there is a small number of crowded cities, including the capitals of many countries [1], [2]. Nowadays, the crowded cities are increased and raised big challenges to control this situation [3], [4]. The population density is measured by a number of people per square kilometer, for this aspect Fig. 1 shows the most population density of cities over the world at 2015, these crowded cities at population leading to crowded roads [5], [6]. According to this high intensity of population distribution, so this aspect leading to big amount of cars circulating these heavy roads crowded cites [7], [8], [9], [10]. This makes it urgent to find solutions for car parking [11], [12]. Today, the traditional car parking becomes inefficient to cover the advanced revolution in car industry [13], [14].

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The big growth of cars through cities causing many problems such as traffic congestion, time delay, and fuel consumption. These factors are affecting directly business, economy, and health and cause big losses on these issues. Hence, it is an efficient option to solve these problems, and when cars are directed to the near car parking, this aspect gives a good solution to the environment. In 2017 about one million vehicles were on Amman's streets between 9:00 am and 10:00 am according to an official at the Greater Amman Municipality.

This research aims try to study the traffic at Amman city according to a high number of cars circulated each day in this city. In addition, a significant number of cars comes from outside of Amman city each day. All these cars need to be find the nearest parking place, so this is the main objective of the research.

2. LITERATURE REVIEWS

As the number of vehicles growth rapidly, it becomes a big challenge to overcome this aspect. Many papers are published

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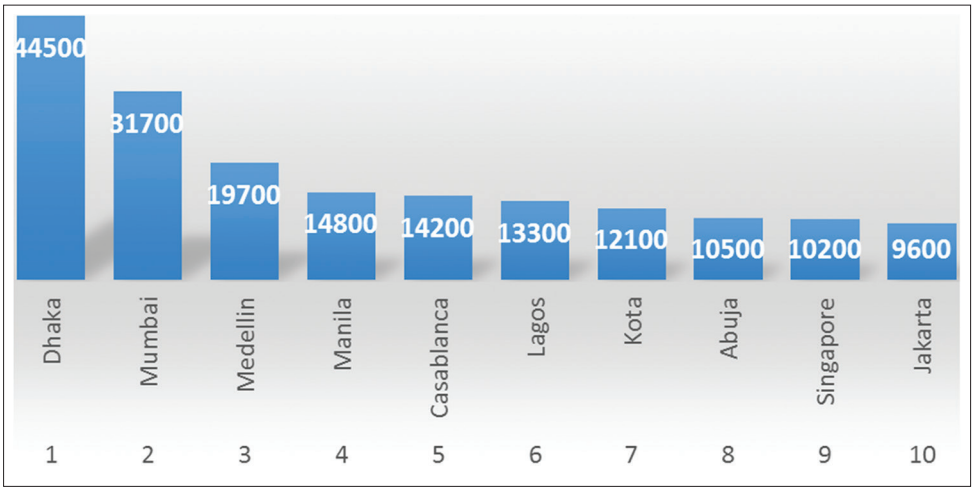

Fig. 1. Most population density of cities over the world at 2015

for design and implementation of different parking systems. Below some of literature reviews explained this issue.

Zhu *et al.* compared the energy available on the car dashboard to power the wireless labels in the car for asset tracking and parking applications. Three energy sources available on the dashboard of a vehicle were studied, namely vibrational energy, thermal energy, and light energy. The area available for the energy harvester is the same as that of a credit card. Simulations were performed to estimate the potential electric power that can be generated from the three energy sources. It has been found that a vibration harvester can generate tens of μW in all weather conditions. The other two types of energy harvesters can generate tens of mW per sunny day. However, the output power of a thermogenerator falls to 0, while the power density of a solar cell falls to 40% in a cloudy or rainy climate [15].

Shin *et al.* proposed algorithm helps drivers find the most appropriate parking given the real-time status of parking facilities in a city. To suggest the most appropriate parking, several factors are taken into account, such as the distance from the guided parking, the walking distance from the guided parking to the destination, the expected parking costs, and the congestion caused by the parking guide. To evaluate the effectiveness of the proposed algorithm, simulation tests were performed. The proposed algorithm maximizes the use of a city's space resources and reduces unnecessary energy consumption and CO_2 emissions from roving cars, as it is designed to effectively control parking use and reduce congestion [16].

Levy *et al.* presented PARK FIT, a new algorithm for estimating urban parking patterns based on a spatially explicit high-resolution vision of the supply and supply of urban parking that is inherently heterogeneous. This system was used to assess the adequacy of the demand for overnight parking and parking capacity in the city of Bat Yam, both currently and as part of the Bat Yam 2030 Master Transportation Plan using high-resolution data obtained. Then, they analyze the capabilities and limitations of this system and provide it as a free software based on ArcGIS [17].

Belloche purposed a model to search time for on-street parking. The modeling is based on Axhausen's proposal for off-street parking, but the specific characteristics of street parking allow several models to be taken into account to estimate the search time for parking on the street. These models face a survey carried out in several districts of Lyon. The results of this confrontation provide interesting conclusions about the modeling of the investigation time of street parking, validation, and other research needs to improve the solidity of the model [18].

Alkheder *et al.* focused on two aspects. First, a survey was prepared and distributed to 500 participants as part of a project to identify the scale of the parking problem in Abu Dhabi. Then, a technical framework was developed to develop a smart mobile application to improve the indoor parking management system in Abu Dhabi. The results indicate that the proposed mobile application will help to reduce the time lost in the search for parking and increase the efficiency of the parking system in Abu Dhabi [19].

Atif *et al.* presented a continuous work program that contributes to new business solutions and cutting-edge research impacts. They reveal a PSP-multilayer business

model through interdisciplinary research blocks where the original results are expected in each layer. This article reveals a work in progress to take advantage of private properties for parking, to relieve stress in public bodies, create new sources of income, and attract new entities in the middle market. The internet of things (IoT) paradigm extends the reach of smart cloud-based parking services in smart cities, with new applications that better regulate car parking traffic [20].

Bischoff *et al.* demonstrated the integration of a parking search simulation in Multi-Agent Transport Simulation. This includes the integration in the agent simulation logic using a daily planning methodology, separation of car trips of several segments for each travel segment, a parking search behavior, and a data structure for each trip segment. The parking search model is applied in a case study for an area in Berlin, Germany. Compared to a standard simulation without parking search, the results suggest that parking search traffic represents up to 20% of the total traffic in a residential area and has a significant impact on the total travel time of the agents traveling in car [21].

Christiansen *et al.* used the data set from the 2013 National Travel Survey (NTS), which includes approximately 60,000 interviews of people 13 years of age and older. A sample of more than 2000 inhabitants of the city of this NTS was selected for an extensive parking survey. They asked detailed questions about the parking of the house. NTS 2013 and the parking survey were merged, and travel patterns and contextual variables were linked to detailed information on parking availability. This has provided an excellent opportunity to analyze how variations in parking facilities affect the travel and ownership of a car [22].

Thomas and Kovoor explained the valuable time and fuel of the customer that is wasted and they have little time to do their shopping. Authorities are struggling to cope with this situation, even after designating more personnel to manage traffic in the bay. A smart parking system that could raise this problem is an urgent requirement for the mall. This document throws light on this issue when proposing a new prototype for the intelligent parking system of automobiles. A genetic algorithm approach has been adopted to solve the problem of programming the vehicle in the parking area [23].

Nourinejad *et al.* introduced the optimal design of the minimum relocation car parks; they presented a non-linear mixed program that treats each island of the car park as a system of queues. They solve the problem using the decomposition of Benders to obtain an exact answer and present a heuristic algorithm to find a reasonable upper limit of the mathematical model. They showed that autonomous parking can reduce the need for parking spaces by an average of 62% and up to 87%. This revitalization of the space previously used for parking can be socially beneficial if the parking lots are converted into commercial and residential uses [24].

Most of the related works are concentrated on the parking spaces, parking positions, the relationship between population

TABLE I
First Level of Map Division

S1	1	2	3	4	5	6	7	8	9
1	S1(1,1)	S1(1,2)	S1(1,3)	S1(1,4)	S1(1,5)	S1(1,6)	S1(1,7)	S1(1,8)	S1(1,9)
2	S1(2,1)	S1(2,2)	S1(2,3)	S1(2,4)	S1(2,5)	S1(2,6)	S1(2,7)	S1(2,8)	S1(2,9)
3	S1(3,1)	S1(3,2)	S1(3,3)	S1(3,4)	S1(3,5)	S1(3,6)	S1(3,7)	S1(3,8)	S1(3,9)
4	S1(4,1)	S1(4,2)	S1(4,3)	S1(4,4)	S1(4,5)	S1(4,6)	S1(4,7)	S1(4,8)	S1(4,9)
5	S1(5,1)	S1(5,2)	S1(5,3)	S1(5,4)	S1(5,5)	S1(5,6)	S1(5,7)	S1(5,8)	S1(5,9)
6	S1(6,1)	S1(6,2)	S1(6,3)	S1(6,4)	S1(6,5)	S1(6,6)	S1(6,7)	S1(6,8)	S1(6,9)

TABLE II
Second Level of Map Division

S11	1	2	3	4	5	6
1	S11(1,1)	S11(1,2)	S11(1,3)	S11(1,4)	S11(1,5)	S11(1,6)
2	S11(2,1)	S11(2,2)	S11(2,3)	S11(2,4)	S11(2,5)	S11(2,6)
3	S11(3,1)	S11(3,2)	S11(3,3)	S11(3,4)	S11(3,5)	S11(3,6)
4	S11(4,1)	S11(4,2)	S11(4,3)	S11(4,4)	S11(4,5)	S11(4,6)
5	S11(5,1)	S11(5,2)	S11(5,3)	S11(5,4)	S11(5,5)	S11(5,6)
6	S11(6,1)	S11(6,2)	S11(6,3)	S11(6,4)	S11(6,5)	S11(6,6)

and number of cars and number of car parking, transport simulation, smart parking, etc. This research aims to design an effective control parking to minimize time as possible and to reduce congestion.

3. METHODOLOGY

The methodology of this approach including Amman city as a case study to design and implement the system, car parking design in which the design of the overall building with networks and sensors, and finally the IoT that deal with the adaptation of the system through the future aspects of IoT.

A. Amman City: Case Study

Amman city is selected as a case study to demonstrate the implemented approach. Amman is the capital of Jordan. Amman is situated in north-central of Jordan. Amman has a population of 4,007,526 and a land area of 1680 km^2. Today, Amman is a major tourist destination in the region, particularly among Arab and European tourists.

The number of vehicles registered with the Department of Licensing of Drivers and Vehicles reached 1,420,951 vehicles at the end of last January 2016, and consequently, there are about one million vehicles in Amman. Hence, there are about 595 vehicles in each 1 km^2.

The first step (first level of squares) (Table I) Amman map is divided into a square (9*6 = 54), according to Amman land area of 1680 km^2, so each square is about 31.1 km^2, and each square is of size 5.58*5.58 km as shown in Fig. 2. In addition, there are about 18,518 vehicles in each square, but this number is as an average only. Really the city center is more crowded and has more streets than the border.

The second step (second level of squares) (Table II) in which each square of the first level is divided into smaller squares (6*6 = 36), so each small square (S11) has the area of about 0.864 km^2 (864000 m^2). At this level, the square size is about 930*930 m.

The third step (third level of squares) (Table III) in which each square of the second level is divided into more smaller squares (6*6 = 36), so each more smaller square (S111) has the area of about 24000 m^2. At this level, the square size is about 155*155 m.

According to the third level, there are 36 squares of size 155*155 m, so if this size is divided into three parts as shown in Fig. 3. The car parking's are situated at the corners of a square situated at the center of each bigger square (denoted by green color), this means any driver position can reach its parking destination within a distance between 44 and 62 m.

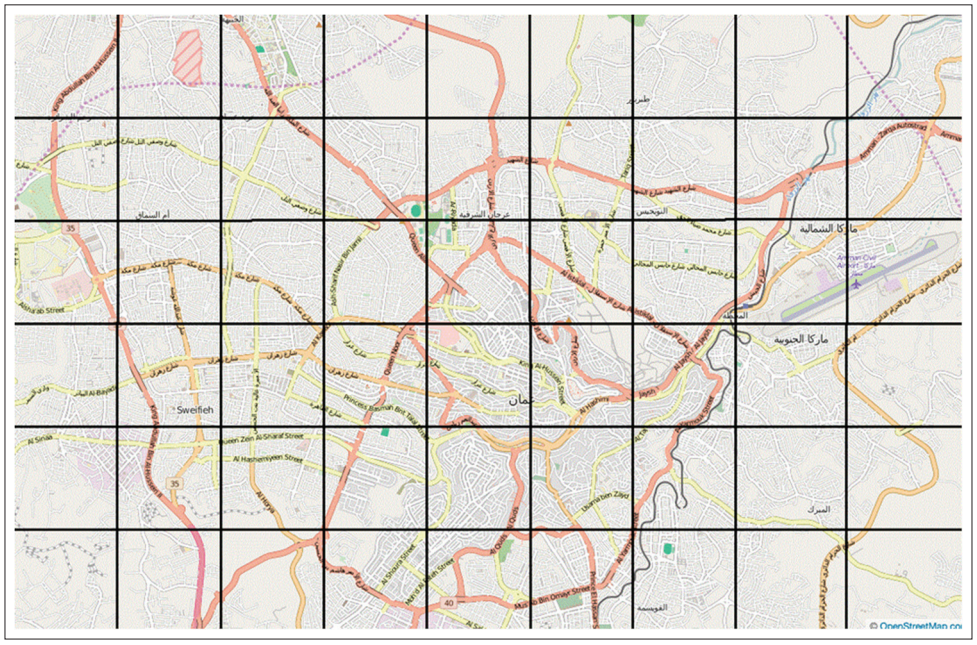

Fig. 2. Amman map divided into square

B. Car Parking Design

Car parking design is divided into two parts: Inside car parking and outside car parking. The inside design started with the area of 25*25 m2 with ten plants. The structure of each plant is divided into 10 car places with two sides. Each car park is equipped by one digit screen (0-9) and a lead sensor in which the green color indicates empty place and the blue color indicates the busy place as shown in Fig. 4.

At the gate of each plant, there is a screen indicates the empty places in that plant, in addition, there is a screen at the main gate of the garage indicates which plant have empty places. All these information collected directly from sensors located in each plant and each car parking place.

The outside car parking is a communications system that has information of all the parking places at the city. That information including size of the park, have empty places or no, the distance from the driver position, and the guided direction to the destination.

C. IoT through Raspberry Pi

The future of the world is directed to the IoT, so the implemented system has the ability to synchronize with the IoT. The overall system is constructed from devices, sensors, and networks, so it is so easy to adapt this system with IoT.

The main part of this approach is adapting the Raspberry Pi which has the ability to operate in real time. Many generations of Raspberry Pi have been manufactured. The 1G of Raspberry Pi-1 was released in February 2012; the 2G is Raspberry Pi-2 which added more RAM was released in February 2015, and the 3G of Raspberry Pi-3 was released in February 2016 that adapted onboard WiFi and Bluetooth.

Raspberry Pi-3 is a microcomputer that has the ability to work in real time including managing all the required operations of the implemented system such as detection, capturing, and tracking of information. Raspberry Pi-3 has the ability to simulate various applications in our daily life with a flexible platform. The architectural design of Raspberry Pi is shown in Fig. 5. The hardware car parking implemented the system using Raspberry Pi is shown in Fig. 6. This system you have the ability to interact, transiting and receiving, control, and working at the real time. That means all the functions (according to car parking information and processing) through the implemented approach can be run at a real time without any delay.

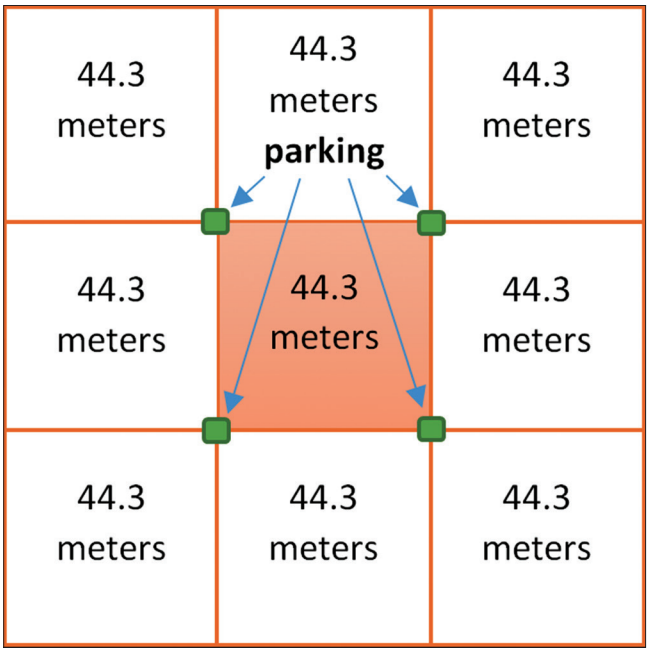

Fig. 3. Car parking places

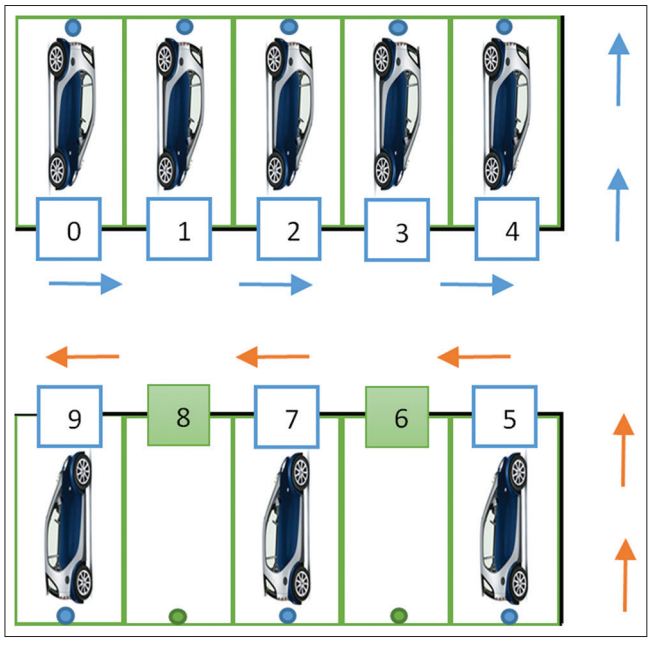

Fig. 4. One plant of parking building

D. Intelligent Car Parking Approach

The intelligent car parking approach based on the following aspects:

- Equipped each plant with sensors situated in each car parking place for carrying the information of the car parking place that is busy or empty.

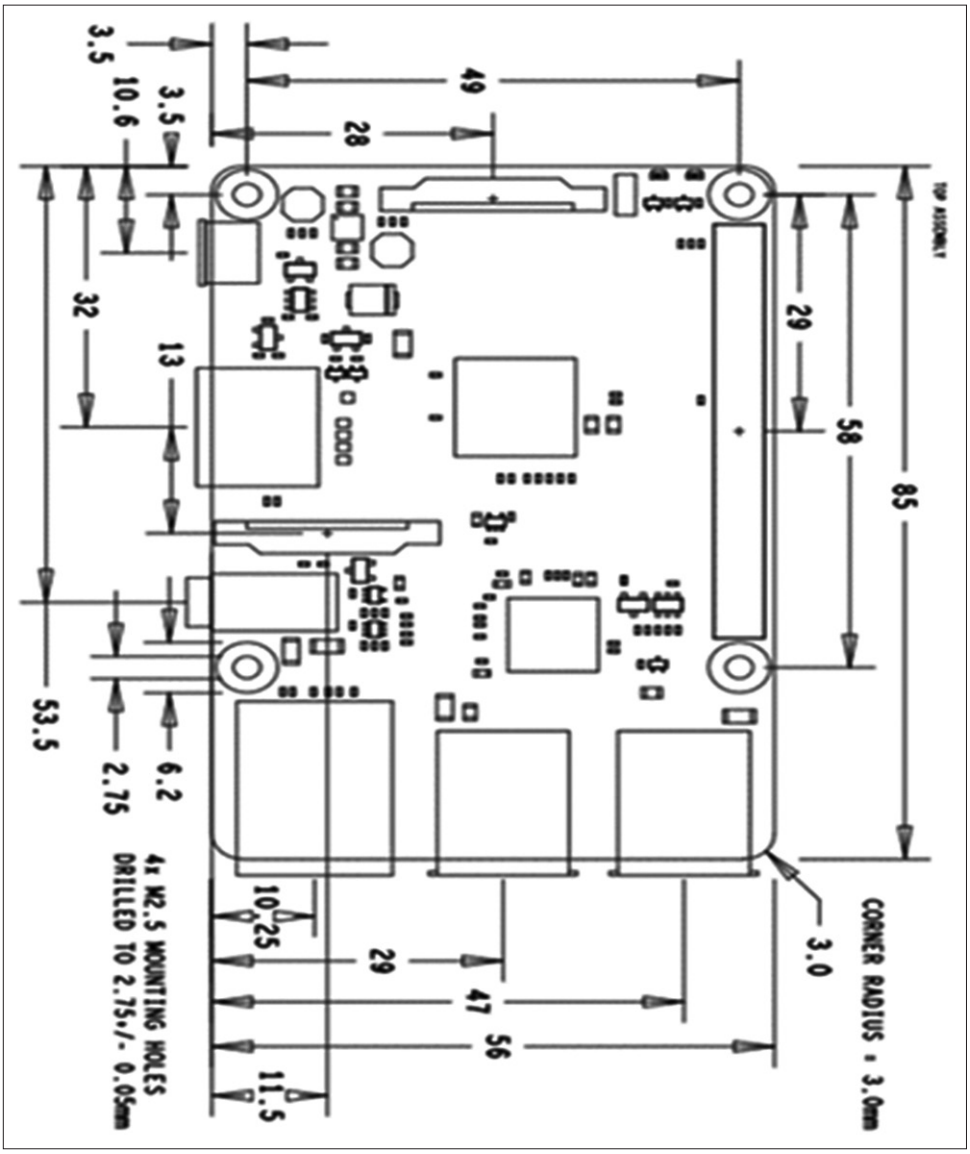

Fig. 5. Raspberry Pi architecture

TABLE III
Third Level of Map Division

S111	1	2	3	4	5	6
1	S111(1,1)	S111(1,2)	S111(1,3)	S111(1,4)	S111(1,5)	S111(1,6)
2	S111(2,1)	S111(2,2)	S111(2,3)	S111(2,4)	S111(2,5)	S111(2,6)
3	S111(3,1)	S111(3,2)	S111(3,3)	S111(3,4)	S111(3,5)	S111(3,6)
4	S111(4,1)	S111(4,2)	S111(4,3)	S111(4,4)	S111(4,5)	S111(4,6)
5	S111(5,1)	S111(5,2)	S111(5,3)	S111(5,4)	S111(5,5)	S111(5,6)
6	S111(6,1)	S111(6,2)	S111(6,3)	S111(6,4)	S111(6,5)	S111(6,6)

- Equipped each plant with one digit screens situated at the gate of each car parking place for indication the car parking place is busy or empty.
- Equipped each plant by a screen situated at the gate of each plant for indication the car parking is busy or empty.

- Equipped each plant by Raspberry Pi 3 situated at the gate of each plant. This device works as a microcomputer to control the operation of the overall system.
- Equipped each plant by the powerful router to achieve a wireless network between all equipment's of the plant.
- Equipped a network connection between the 10 plants into a central unit that controls and transmit data of the main part of the plants.
- Equipped an efficient screen on the main gate of the garage to display the situation of the garage instantaneously.

4. DISCUSSIONS

The overall system (mobile driver) can be installed on smart mobile devices, in which the driver with his mobile device can access the car parking system to allocate the suitable place for his car. The first part of this approach starts working when the driver starts to access the car parking system. This system allocates on the two nearest car parking places with empty places, so the driver must select the most suitable one in which he will have all the information about that park including position, distance, and direction as shown in Fig. 7.

The second part of this approach starts working when the car is reaching the main gate of the garage, in which the system has enough information about the places so the driver will get a number associated with a number of the car place, so the driver guides his car to the indicated place. A simple security issue is suggested through integrating and merging both the car license plate number and the associated number to generate a secure number that can verify when there is any problem.

5. CONCLUSIONS

The crowded cities are leading to many environmental problems such as ambient pollution. The aim of adequate car parking leading to localize the nearest car parking position in which reduce pollution in crowded cities, reduce the traffic congestion and minimize the required time to reach the destination. The proposed car parking system has two main subsystems.The external subsystem that covers all the communications between cars and guiding cars to its nearest park. The internal subsystem that covers all the function enter the park and guided the car to its final destination. The implemented system compensate and minimize the time for finding the car parking as well as reducing the traffic congestion, that leading to minimize the pollution.

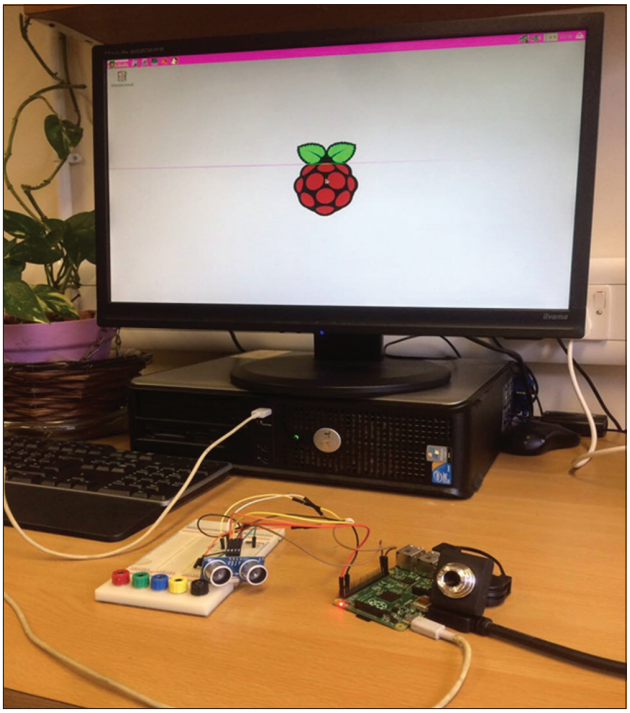

Fig. 6. System connection

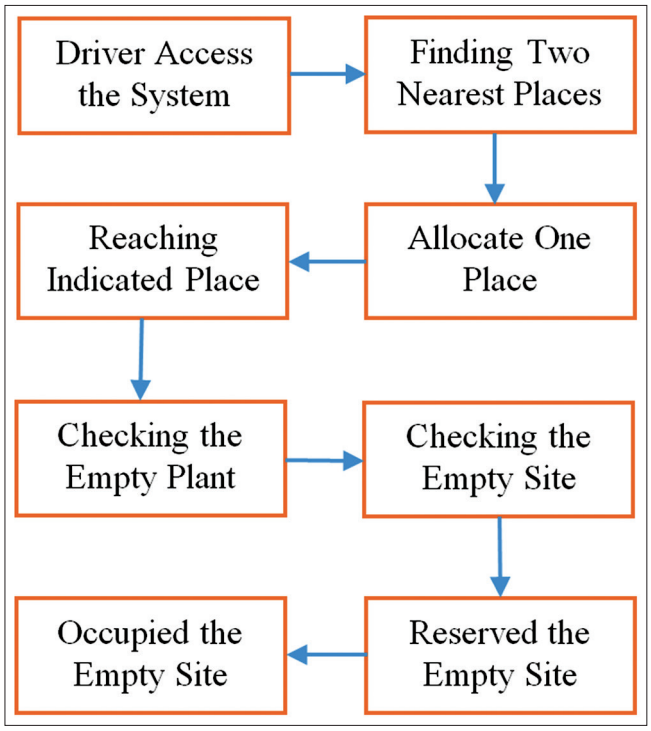

Fig. 7. The implemented system procedure

Integrating and indexing cars and car parks leading to solve an important issue in the future IoT. This research studies

the overall environment of Amman city and the best arrangement of the car parking positions. The proposed future works of this research are how to realize these factors in a real environment.

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