Static and dynamic water wells levels of Kirkuk city represented by geo-statistical algorithms in GIS

Ghadah Mohammed¹

¹ Northern Technical University, Kirkuk, Iraq

Abstract. Water is great importance for human life as well as for agriculture therefore, different scientific methods are used for curtailed the time and possibilities for well water sources investigation. Fresh water is the most importance for Human life and cannot be healthy without it. In the paper two different interpolation methods were used, which are the ordinary kriging and Inverse Distance Weighting (IDW) to predict static and dynamic water levels of wells in Kirkuk City, and the number of wells was 64. The data of wells were obtained from digging water wells in Directorate of Kirkuk. By using different methods different results were introduced. Furthermore, three wells were used as testing wells for interpolation algorithms. These are office of the Nation Mission, the Emergency department, and Wahid Athar district wells and it was found that the Emergency department well is the most accurate and nearest from the actual levels for both static and dynamic with RMSE of – 2.23 and – 1.35 in kriging method respectively as well as – 2.97 and – 2.65 respectively in IDW method. However, the average of the three testing wells overall IDW interpolation algorithm is the best, accurate and nearest from the true elevations in stable levels of wells.

1 Introduction

With the necessary human needs for water, the various scientific methods used to increase saving time and possibilities to search for well water sources. Fresh water considered the most important for human life, as life itself is not possible without it. Also fresh water cannot be substituted by anything else. Fresh water and the various natural surface water bodies had used and consumed by human for a wide range of purposes (1). At the same time, in many Western Asian countries the further extraction of surface and groundwater resources through the subsidization and centralization of large- and small-scale agricultural production result from changing development paradigms and political uncertainties prompted the adoption of national policies to pursue food security through food self-sufficiency (3).

There is an ever-growing demand for information on groundwater hydrology and on the hydraulics of the movement of water in aquifers because groundwater plays an important role in the developing and managing of water resources. (2). Therefore, the search, store and use them, as an alternative is necessary for surface water. The method used wells to extract groundwater from the earth in various depths and the various compounds contained in the water and by the geology of the ground core. Static and dynamic water levels were predicted in this study.

During the few years, the most popular computer program is the Geographic Information System (GIS). By GIS program the data cannot acquire, always updating, as

well as we can analyzing and modelling the data by it (5).

Many studies by GIS were prepared for processing region and city center. (4) a Hydrogeological study about Adana city settlement by GIS program. Water quality analyze maps prepared and groundwater level maps. Researches were prepared for aquifers and basins of larger areas with the same way.

In this study, static and dynamic water levels of wells in the Kirkuk City were selected, which are 64 wells. The geographical locations of the wells were converted to the UTM coordinates system by using website to convert them online. Then, I corrected the coordinates of some wells locations by our experience about the study area. For prediction the static and dynamic water level of Kirkuk City, the interpolation analyst in GIS with two difference methods were used, which are Kriging and Inverse Distance Weighting (IDW). Furthermore, I compared between the two interpolation methods after testing them by three wells. The main objectives of this study are generating data for wells for areas that unobserved or do not have available wells as well as comparing different geostatistical interpolation methods and choosing the best one close to the.

2 Material and methods

In this paper, geo-statistical algorithms ordinary kriging and Inverse Distance Weighting (**IDW**) used to predict static and dynamic water levels of wells in the selected area (Kirkuk City) which are 64 wells. The data and

information of wells Kirkuk city obtained from digging water wells Directorate of Kirkuk.

3 Study area

Fig. (1) Shows Kirkuk City located in north of Iraq is the capital of the Kirkuk province. A city located at longitude 44° 00'E to 44° 50' E and latitude 35° 13' N to 36° 29' N with a total area of 96.79 km². It is 236 kilometers north of the capital, Baghdad. The average elevation of Kirkuk is 346 meters. Kirkuk is located in a vast area with a very diverse population and dramatic demographic changes in the twentieth century. Kirkuk has multilingual, and the development of distinct ethnic groups was a process that took place throughout the twentieth century of urbanization in Kirkuk.

Fig. 1. Location map of study area and observation water wells.

4 Interpolation methods

4.1 Ordinary kriging

Kriging is a geo-statistical interpolation method, which is the statistical models that include autocorrelation based on statistical models—which is, the statistical relationships among the measured points. That is the reason behind the geo-statistical techniques capable to predict the surface of the production in addition to that it provides a certainty measurements or precise predictions.

Kriging's theory presumably that the direction or distance among sampling points reflects a spatial link which, can be used to illustrates the variation in the surface. This tool commensurate with the mathematical function for some points or all points within a specified radius for determining the output value for each location. Kriging tool are a multi-stage operations. It involves modeling of variables, exploratory statistical analysis of

data, (optionally) exploring the surface of variance, as well as creating a surface. Kriging is the best tool when there is directional bias in the data or a spatially connected distance. They often used in geology and soil science (6).

$$\bar{Z}(S_0) = \sum_{i=1}^N \lambda_i Z(S_i) \quad \text{Where:} \quad \text{.....1}$$

$Z(S_i)$ = the value measured at the i th location
 λ_i = an unknown weight for the value measured at the i th location
 S_0 = forecast site
 N = the number of values measured

4.2 Inverse Distance Weighted (IDW)

Inverse Distance Weighted is the simplest, most readily, and one of the most precise techniques of interpolation. The assumption behind IDW is that the value of non-sampled points can estimated as a weighted average of values at sampled surrounding points As much; the surrounding sampled points are near to the non-sampled point, as the value accuracy of the point increases (7).

$$Z_0 = \frac{\sum_{i=1}^N \frac{Z_i}{d_i^{-n}}}{\sum_{i=1}^N \frac{1}{d_i^{-n}}} \quad \text{.....2}$$

Z_0 = the estimation value of variable z in point i .

Z_i = sample value in point i .

d_i = distance between sample point and estimated point.

N = A coefficient that determines weigh based on a distance.

5 Results and discussion

5.1. Interpolation results

5.1.1 IDW interpolation of static elevation

Fig. (2) Shows the IDW interpolation method for elevation map of Kirkuk City wells. We can classify the stable elevations in to four main classes, which are very high, high, moderate, and low. The first class is starting from 256.2079322 cm to 268.1243654 cm, from 268.1243655 cm to 294.9363403 cm, which represents the highest stable elevation represented by white and light purple colors, and distributes in the north part of study area. The second class is starting from 219.8628107 cm to 240.7165688 cm and from 240.7165689 cm to 256.2079321 cm illustrates the high class, which is the

dark purple and dark brown colors and distributes in the center, east, and west parts of study.

Fig.2. IDW interpolation of Stable elevation map for

wells of Kirkuk city.

area. The third class is starting from 185.3051541 cm to 201.392339 cm, from 201.3923391 cm to 219.8628106 cm, illustrates the moderate class represented by light brown and light yellow colors, and distributes in the center, and eastern and western south parts of study area.

The fourth class is starting from 143.0018158 cm to 170.4096124 cm, from 170.4096125 cm to 185.305154 cm and the low class represented by celestial and off-white colors, and distributes in the south and western south parts of the study area map.

5.1.2. IDW interpolation of Dynamic elevation

Fig. (3) shows the IDW interpolation method for dynamic elevation map of Kirkuk City wells. We can classify the stable elevations in to four main classes, which are very high, high, moderate, and low. The first class is starting from 273.3054678 cm to 287.2524524 cm, from 287.2524525 cm to 311.927887 cm illustrates most high stable elevation represented by orange and dark red colors, and distributes in the north part of study area. The second class is starting from 243.8022308 cm to 258.8220604 cm and from 258.8220605 cm to 273.3054677 cm illustrates the high class, which is the yellow and green colors and distributes in the center, east, and west parts of study area. The third class is starting from 209.4711914 cm to 225.5638661cm and from 225.5638662 cm to 243.8022307 cm, clears the moderate class represented by dark blue and celestial colors, and distributes in the center and eastern and western south parts of study area. The fourth class is starting from 175.140152 cm to 198.7427415 cm and from 198.7427416 cm to 209.4711913 cm and clears the low class represented by pink and white colors and distributes in the south, eastern and western south parts of the study area map.

Fig. 3. IDW interpolation of dynamic elevation map for wells of Kirkuk city.

5.1.3 Kriging interpolation of Stable elevation

Fig. (4) states the kriging interpolation method for Stable elevation map of Kirkuk City wells. The stable elevations can be classified in to four main classes, which are very high, high, moderate, and low. The first class is starting from 267.7103578 cm to 286.4908393 cm, from 286.4908394 cm to 299.6371765 cm illustrates most high stable elevation represented by red and dark orange colors, and distributes in the north part of study area. The second class is starting from 227.0193141 cm to 247.0518278 cm and from 247.0518279 cm to 267.7103577 cm illustrates the high class, which is the light orange and yellow colors and distributes in the center, east, and west parts of study area. The third class is starting from 184.4502223 cm to 205.1087521 cm and from 205.1087522 cm to 227.019314 cm, clears the moderate class represented by light yellow and light green colors, and distributes in the center and eastern and western south parts of study area. The fourth class is starting from 140.00308823 cm to 160.6616121 cm and from 160.6616122 cm to 184.4502222 cm and shows, the low class represented by light green and dark green colors and distributes in the south part of the study area map.

5.1.4. Kriging interpolation of Dynamic elevation

States the kriging interpolation method for Dynamic elevation map of Kirkuk City wells. We can classify the elevations in to four main classes, which are very high, high, moderate, and low. The first class is starting from 283.7948575 cm to 304.3256078 cm, from 304.3256079 cm to 316.5330811cm illustrates most high stable elevation represented by dark red and dark orange colors, and distributes in the north part of study area. The second class is starting from 246.0626676 cm to 262.1543368 cm and from 262.1543368 cm to 283.7948574 illustrates

the high class, which is the light orange and desert colors and distributes in the center, east, and west parts of study area. The third class is starting from 212.2146737 cm to 228.3063428 cm, from 228.3063429 cm to 246.0626675 cm, clears the moderate class represented by grey and light grey colors, and distributes in the center, and eastern and western south parts of study area. Fig. (5) illustrate the fourth class is starting from 175.0373688 cm to 198.3425449 cm and from 198.342545 cm to 212.2146736 cm and clears, the low class represented by light and dark blue colors and distributes in the south, eastern and western south parts of the study area map.

Fig. 4. Kriging interpolation of Stable elevation map for wells of Kirkuk city.

Fig. 5. Kriging interpolation of Dynamic elevation map for wells of Kirkuk city.

5.2 Validation

Three wells used to test the interpolation methods, which are Office of the United Nations Mission well, the emergency department well, and Wahid Athar district well. The testing wells distributed on study area by homogeneous form. After that, the testing wells checked with the interpolation predict information to examine the validation of each methods i.e. ordinary kriging and IDW

methods. The results of testing are illustrated in Table 1 & 2, as follows: in kriging method, the Emergency department well was the most accurate and nearest from the actual levels, where the difference in level between the testing and interpolation result for both static and dynamic with -2.23 cm and -1.35 cm, respectively. Likewise the same testing well which is the Emergency department got accurate and closer results from IDW interpolation method, where 2.97 cm and -2.65 cm for static and dynamic respectively. And so on, the average difference level of the three testing wells overall IDW interpolation algorithm is the best, accurate and closer from the true elevations in stable levels of wells.

Table 1. Validation in levels between Testing wells water level and Ordinary Kriging Method.

ID	NAME	SL	DL	SLK	DLK	DSL	DDL
T1	OOTUM ¹	274	280	264.36	284.05	9.64	-4.05
T2	TED ²	192	196	194.23	197.35	-2.23	-1.35
T3	WAD ³	192.3	216.3	181.82	183.75	10.48	32.55
Average Difference Level						17.89	27.15

Table 2. Validation in levels between Testing wells water level and Inverse Distance Weighted IDW Method.

ID	NAME	SL	DL	SLK	DLK	DSL	DDL
T1	OOTUNM ¹	274	280	262.05	280.93	11.95	-0.93
T2	TED2	192	196	194.97	198.65	-2.97	-2.65
T3	WAD3	192.3	216.3	187.53	198.18	4.77	18.12
Average Difference Level						13.75	14.54

Where:

OOTUNM¹: Office of the United Nations Mission

TED²: The emergency department

WAD³: Wahid Athar district

6 Conclusions

Using different interpolation methods for prediction a static and dynamic water levels methods can give more options to indicate the more accurate one. The single interpolator cannot produce chief results for the generation of static and dynamic water levels maps, therefore we always using two-interpolation method. Four maps was produced, two for static water level in two methods ordinary kriging and IDW and they give some difference in spatial distribution of the static level due to the difference in equation and mechanism of each method. Furthermore, another two maps for dynamic water level as well same to previous two maps that produced by two different interpolation methods ordinary kriging and IDW with some difference in results of spatial distribution of dynamic water levels of wells. Generally, by using the validation technique for evaluation, all of the methods gave similar RMSE values. The method used in this study (kriging method) had better performance for pH in surface of soil also the lognormal kriging excellence both IDW and splines to interpolating electrical conductivity in surface soils. To identify most accurate interpolation method, three testing wells had used to validate which method is the best. The Emergency department well was the most accurate and

nearest to the truth results of both static and dynamic water levels and even by using both ordinary kriging and IDW methods. However, IDW interpolation algorithm was the best, accurate and nearest than the ordinary kriging in overall average difference between testing and predicting stable and dynamic water levels of wells.

Acknowledgment

The author would like to express my thanks to the staff of the general commission for groundwater. Especially the Head of Department Dr. Ahmed Nazem, And I have to extend my sincere thanks to Eng- Fouad Mohammed sadiq . For his advice during my research. In addition, I have to extend my sincere thanks to Mr. Ali jassim nayyef and Mr. Sabah Ahmed Khorshid for their advice during work in my research.

References

1. Shiklomanov, Igor A. "World water resources." A new appraisal and assessment for the 21st century (1998).
2. Bear, Jacob. Hydraulics of groundwater. Courier Corporation, 2012.
3. Brander, Luke M., et al. Ecosystem Services 1.1 (2012): 62-69.
4. Çobanoğlu, İbrahim, Et Al. "Coğrafi Bilgi Sistemi (Cbs) Kullanılarak Adana İli Yerleşim Alaninin Hidrojeolojik Özellikleri Ve Su Kalitesinin Değerlendirilmesi."
5. Çelik, Recep. Arabian Journal of Geosciences 8.6 (2015): 4279-4286.
6. Di, Minin Enrico, et al. "Global priorities for national carnivore conservation under land use change." (2016).
7. Ziary, Y., and H. Safari. Proceedings of FIG Working Week. Hong Kong 13 (2007).