Integrative Approach of GIS and Remote Sensing to Represent the Hydrogeological and Hydrochemical Conditions of Wadi Qena- Egypt

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Abstract

The study area is considered as Nile basin fringes. It is also considered as one of the promising areas in the field of development and investment, which is help to go out of the valley and to over come the population increase problem and facilitate new job opportunities.

Using new technologies help effectively in doing research and representation of the results. That is make the decision makers be aware of all conditions belong to the study area in easy and definite forms.

In this paper, an integrative approach of GIS and remote sensing has been used, in addition to other collected data from field investigation and previous studies as a proposed method to represent the hydrogeological and hydrochemical conditions of the study area.

The approach is based on preparing different thematic maps some by using GIS and the others based on satellite images. Weights are assigned to the derived and acquired thematic maps.

Finally, the weighted maps are integrated using GIS to model the hydrogeological and hydrochemical conditions of the study area, which is considered as a support tool for the decision makers. This approach assists the groundwater modelers to have an easy method to formulate the hydrogeological and hydrochemical data in spatial forms and make them suitable for groundwater models.

Keywords: GIS, Remote sensing, Hydrogeology, Hydrohemistry

Introduction

The desert area in Egypt covers an area of about 960,000 km^2, which is approximately 96 % of Egypt. Usually various distinct types of areas are named "desert", whereas the only common feature is their situation within the zone of minimum rainfall In Egypt the desert area can be divided into regions the Eastern Desert region, which includes the Sinai, and the Western Desert region, located respectively east and west of the Nile Valley and Delta.

General Outline

The total area of the Eastern Desert (EO) covers about 220,000 km^2, and is located between the Red Sea and the Nile Valley. It extends from latitude 22 or Egypt's border with Sudan in the south, to the Delta sub region in the north. The Eastern Desert forms an integral part of the Arabian Desert. The broadest features in this area owe their origin to tectonic changes of enormous magnitude occurring in comparatively recent times. The

results are a striking contrast with the Libyan or Western Desert. Generally the Eastern Desert is considered as one of the driest parts of Egypt, nevertheless the activity of water in full flood leaves its traces everywhere in this region.

Geomorphology

The relief of the Eastern Desert influences to a wide extend the occurrence and flow of groundwater, by sculpturing the drainage system and formation of the hydrographic basins. The geomorphological main units in the eastern desert can be described as follows (See figure 1).

A narrow low-lying coastal belt at altitudes rarely exceeding 200 meters;

The eastern discontinuous mountainous range rising above the coastal belt by a steep escarpment parallel to the coast;

A dissected table land: the virtually flat-bedded Nubian sandstone and associated younger formation of the Upper Cretaceous give rise to a highly distinctive morphology, markedly a series of structurally control of scarps, tables and mesas;

A limestone table land flanking the Nile Valley, the undisturbed limestone give rise to flattapped plateaux which boldly dominate the surrounding relief, at altitudes of 400 to 500 meters;

The high massive south Galala Plateau is one of two massive tabular blocks of high relief (1200 meters) which flank the wadi Araba depression, on the northern part of the eastern desert;

The low-lying depression of the Wadi Araba is an anticlinal karstic structure.

Climate

The Eastern Desert occupies a part of the arid zone belt of Egypt. The northern part is affected by the sub-arid belt of the Mediterranean. The area is characterized by hot sununers with temperatures reaching 35°C and by cool winters with temperatures reaching 5"C. The average temperature recorded in the northern part is about 22°C, and about 25°C in the south (Pirard, 1980).

The rainfall is scarce over most of the area and occurs occasionally in storms associated with the south east wind. The average rainfall rates are less than 25 mm/year and increase northward the direction of the Mediterranean and also southward in the direction of Gebel Elba. The relative humidity is about 42-44% in summer time and 46-50% in winter time. North-northwest wind prevails in the northern part and southeast wind prevails in the southern part.

Prior to the present arid nature of the climate, less arid or even wet climatic conditions were dominant (some details are given by Butzer, 1959; Said, 1980; Wendorf, 1977; and Shata, 1992). There is evidence of strong climatic fluctuations, which can be simply presented as follows. From 11,500 to 10,000 BP severe decertification took place. Early Holocene time a sub-pluvial phase occurs. The sub-pluvial phase ended by a phase of declining and fluctuating rainfall. At about 2,500 BP a wet phase occurs. The last phase is characterized by relatively stable dry climatic conditions, prevailing in the past 2,000 years, with some colder periods, like the Little Ice Age during the 16^{th} - 18^{lh} century.

Aquifer Characteristics

In the Eastern Desert, the Quaternary aquifer is represented by wadi sediments and

al1uvial plains. These deposits are developed due to the wadis wfiich traverse the Eastern Desert. Prominent examples in the western part of the Eastern Desert are wadi Qena, Wadi Abbadi, Wadi Natash, Wadi Asyutti, Wadi Laqeta and Wadi El Al1aqi. Prominent examples in the eastern part of Eastern Desert are Wadi Dara, Wadi Bada, Wadi Abu Ghuson, Wadi Hodein, Wadi Kraf, Wadi Lahmi and Wadi Kareim. All these wadis accompany the major collectors fed by the Red Sea Mountains. From a hydrogeological point of view, these aquifers represent local sub basins of individual characteristics. Since dikes and igneous pinnacles act like barriers in the down stream part, they play the main role in storage of groundwater in the upstream wadi deposits, see figure (2).

Recharge And Discharge

The Quaternary aquifer is recharged by local direct rainfall, the river Nile and Lake Nasser. At the fringes of the river Nile some water is infiltrating from the Nile itself, while at the southern part (Lake Nasser) the aquifer is in hydraulic contact with the lake. In the lower parts of the eastern area the wadi deposits are also recharged by ground water from fissures in the basement rocks of the Red Sea Hills, see figure (3).

Most hand-dug wells are dug (at the Quaternary aquifer) through 1 to 25 meters of sand before reaching the water table. The bottom of these wells is normally very close to or within the bedrock, and obtains a regular supply of 10 to 50 m^3 per day.

Groundwater Flow

In the eastern part of the Eastern Desert the ground water flow is directed eastward, where the aquifer is unconfined. The Quaternary aquifer is truncated in the upstream part, while alluvial fans have been developed in the downstream parts.

In the western part of the Eastern Desert, groundwater flow is directed eastward, where the aquifer is unconfined. The wadis are heavily truncated in the upstream and have immense alluvial fans in the down streams.

Hydrochemical Units

Water quality of the Quaternary aquifer is reported to be good, or acceptable. This corresponds to salinities in the range of 750 to 2000 ppm. The flowing is the water analysis of Wadi Qena wells in three sampling rounds; the sampling frequency is one year.

Use of Remote Sensing/Geographic Information System

Geographic Information System (GIS)

Geographic Information System [GIS] is computer-based systems that are used to store, manipulate and display large amount of data that have been encoded in digital form.

In essence, a GIS consists of a series from overlays for a specific geographic region. It enables one to construct a number of data bases and combine them rapidly in multitude of combinations to answer the kinds of question water resources specialists might raise.

GIS have to provide tools for guidance and aiding the users through the extensive process of management, planning, development, monitoring, controlling and disecisions making.

Chemical Analysis of Wadi Qena wells :

well	round	TDS_c	EC25	Al	Cu	Pb	Ca	K	Na	Mg	Cl	SO4	pH
E0005	4	2039.9	3.31	-0.01	-0.002	-0.005	131	14.7	562	51	655.4	469.86	7.35
E0006	4	4005.8	5.7	0.035	-0.002	-0.005	307	12.6	871	115	1475	1133	6.74
E0007	4	3669.2	33.8	0.04	-0.002	-0.005	315	9.18	676	129	1186.2	1239	6.81
E0008	4	1735.7	3.19	0.083	-0.002	-0.005	54.9	7.45	567	30.8	597.2	283	7.63
E0009	4	580.5	0.81	0.029	-0.002	-0.005	21.4	1.93	152	4.43	5.6	177.5	7.97
E0008	6	3276	5.12	0.134	0.006	0.018	292	13.4	692	51.5	1050	680	7.721
E0009	6	1932	3.02	0.096	-0.002	-0.005	32	6.29	569	9.58	703	275	8.489
E0005	6	2246	3.51	0.048	0.011	-0.005	260	14.7	426	46.7	650	580	7.803
E0006	6	4160	6.5	0.033	0.016	0.044	314	14	926	126	1300	750	7.285
E0007	6	3731	5.83	0.147	0.025	0.022	320	9.74	797	85	1200	710	7.742
E0005	7	2227	7.62	0.5	-0.002	0.025	250	23	450	55.68		0	-99
E0006	7	4876	7.68	0.649	0.021	0.063	480	24	970	135		0	-99
E0007	7	4115	7.93	0.648	0.026	-0.005	420	23	790	106		0	-99
E0008	7	821	8.05	0.479	0.034	0.017	140	10	80.57	33.6		0	-99
E0009	7	1618	8.36	0.38	-0.002	-0.005	54	21	740	47		0	-99

Units used in the above table are ppm (mg/ l).

Water is increasingly becoming a scarce resource while its demand continues to grow due to increased socio-economic activities coupled with the ever increasing population.

A geographic information system is a powerful tool for handling spatial data. In G.I.S data are maintained in a digital format. As such the data are in a form more physically compact than that of paper maps, tabulation, or other conventional types. Large quantities of data can also be maintained and retrieved at greater speeds and lower cost per unit when computer-based systems are used. The ability to manipulate the spatial data and corresponding attribute information and to integrate different types of data in a single analysis and at high speed are unmatched by any manual methods. The ability to perform complex spatial analysis rapidly provides a quantitative as well as a qualitative advantage. Planning scenarios, decision models, change detection and analysis, and other types of plans can be developed by making refinements to successive analysis.

Remote Sensing (RS)

It is the acquisitioned data about an object or by a sensor that is far from the object. Aerial photography, satellite imagery, and radar are forms of remotely sensed data.

Fig (4) illustrates the Image of the study area (Wadi Qena) showing the location of samples collected and analyzed to data (Sturchio , 2004). Most of these are from areas adjacent to the Nile Valley latitudes $26^0 00^{\backslash}$ and $29^0 27^{\backslash}$ N, and longitudes 31^0 $16^{\backslash}$ and 59^0 E.

Satellite System is composed of scanner with sensors and a satellite platform.

Image is a digital image in array of elements in which each element corresponds to the reflected or omitted energy from Earth' s surface. Depending on the sensor, digital data fro Remote Sensing techniques are usually stored as 8-bit integers.

There are a lot of applications for Remote Sensing technique. In this paper change detection application using post classification comparison sharing with field investigations was used to detect maps.

Integration of GIS & RS

From the field investigation and the analysis of satellite image and help of GIS it was possible to produce relatively cheap, fast and accurate maps and change map, these maps are useful in planning of groundwater management and development.

Conclusions

- Generally the Eastern Desert is considered as one of the driest parts of Egypt, nevertheless the activity of water in full flood leaves its traces everywhere in this region.
- The relief of the Eastern Desert influences to a wide extend the occurrence and flow of groundwater, by sculpturing the drainage system and formation of the hydrographic basins
- In the Eastern Desert, the Quaternary aquifer is represented by wadi sediments and al1uvial plains. These deposits are developed due to the wadis which traverse the Eastern Desert
- From a hydro geological point of view, these aquifers represent local sub basins of individual characteristics. Since dikes and igneous pinnacles act like barriers in the down stream part, they play the main role in storage of groundwater in the upstream wadi deposits.
- The major supply of water in wadi Qena is the Nubian sandstone aquifer, the potentiality of this aquifer is good. The piezometric heads are equal or higher than the ground level. The thickness of the aquifer reaches 300 to 800 m. At relative shallow depth (less than 500 m.) the groundwater is brackish (TDS more than 4876 ppm). At greater depth 9 more than 500.) The groundwater is fresh (TDS of 580). In Wadi Qena the Quaternary aquifer has some importance because it has a renewable recharge source (Nile water and rain water) ,
- In the lower parts of the eastern area the wadi deposits are also recharged by ground water from fissures in the basement rocks of the Red Sea Hills.
- Most hand-dug wells are dug (at the Quaternary aquifer) through 1 to 25 meters of sand before reaching the water table. The bottom of these wells is normally very close to or within the bedrock, and obtains a regular supply of 10 to 50 m^3 per day.

- In the eastern part of the Eastern Desert the ground water flow is directed eastward, where the aquifer is unconfined. The Quaternary aquifer is truncated in the upstream part, while alluvial fans have been developed in the downstream parts.
- In the western part of the Eastern Desert, groundwater flow is directed eastward, where the aquifer is unconfined. The wadis are heavily truncated in the upstream and have immense alluvial fans in the down streams.
- The groundwater is found at shallow depth (less than 100m.); the salinity of this water depends upon the amount of rainfall.
- Water quality of the Quaternary aquifer is reported to be good, or acceptable. This corresponds to salinities in the range of 750 to 2000 ppm.

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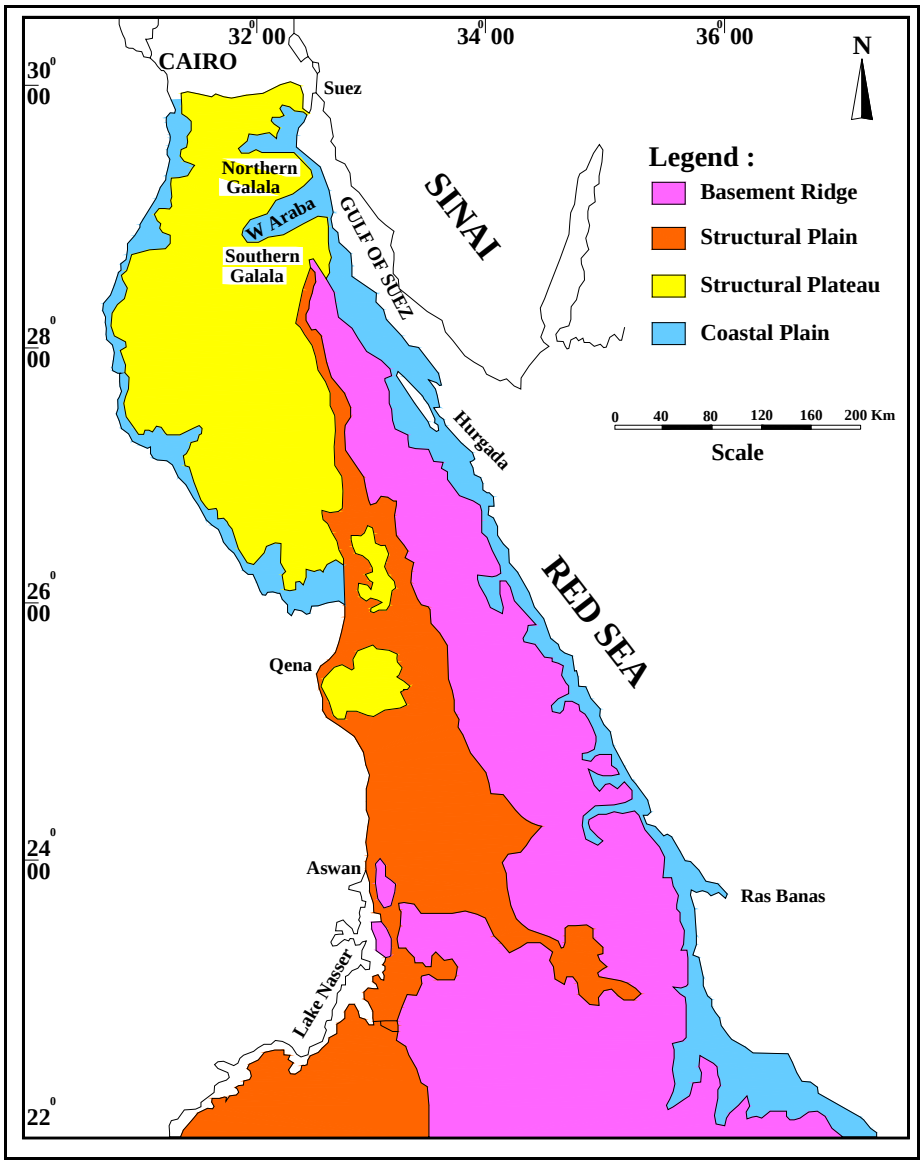

Figure (1) Geomorphological units of the Eastern Desert region

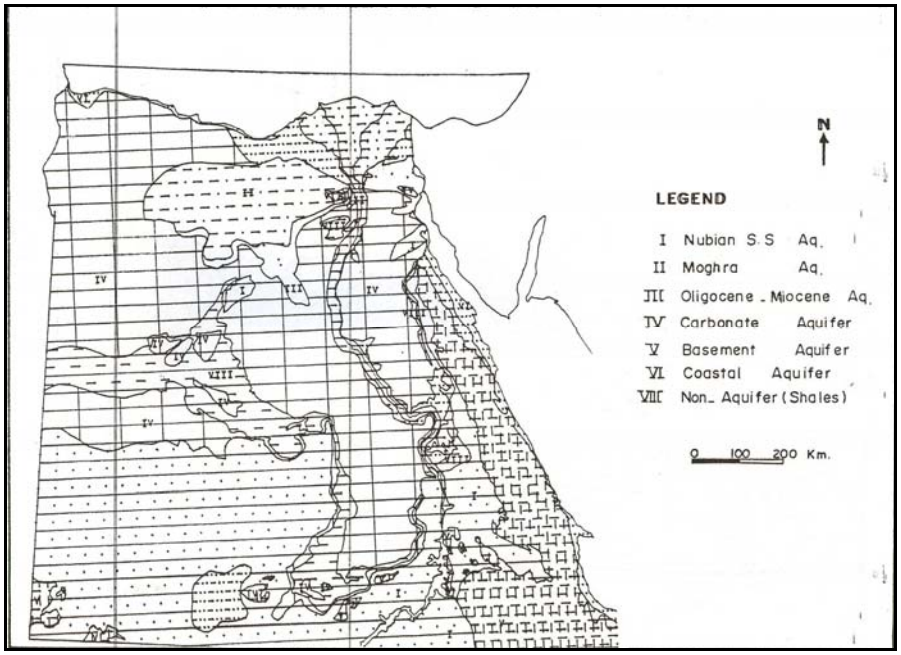

Figure (2) Aquifers of the Desert Area

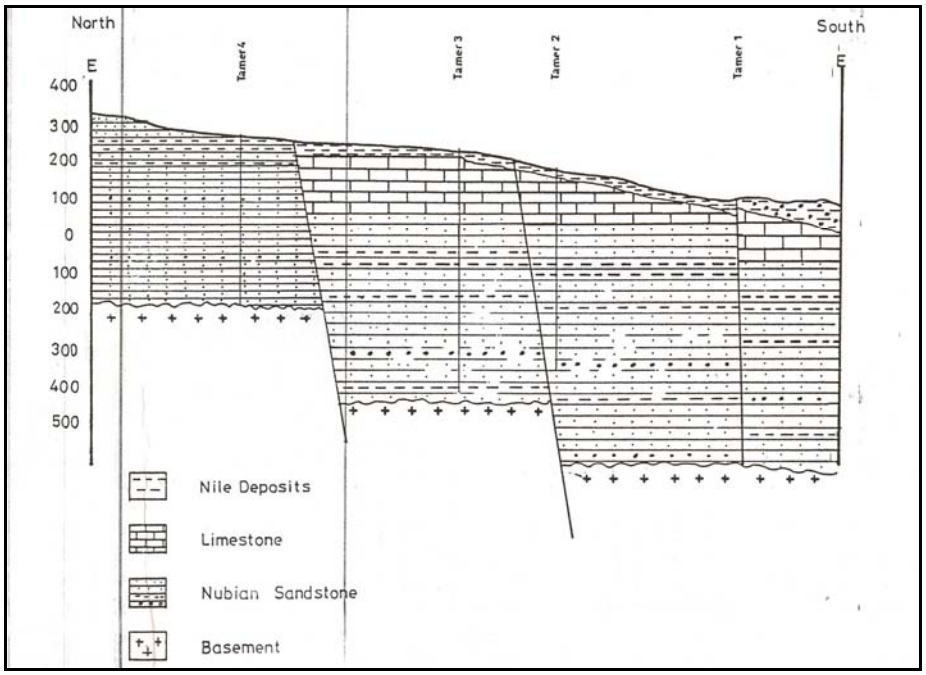

Figure (3) Hydrogeological cross section of Wadi Qena

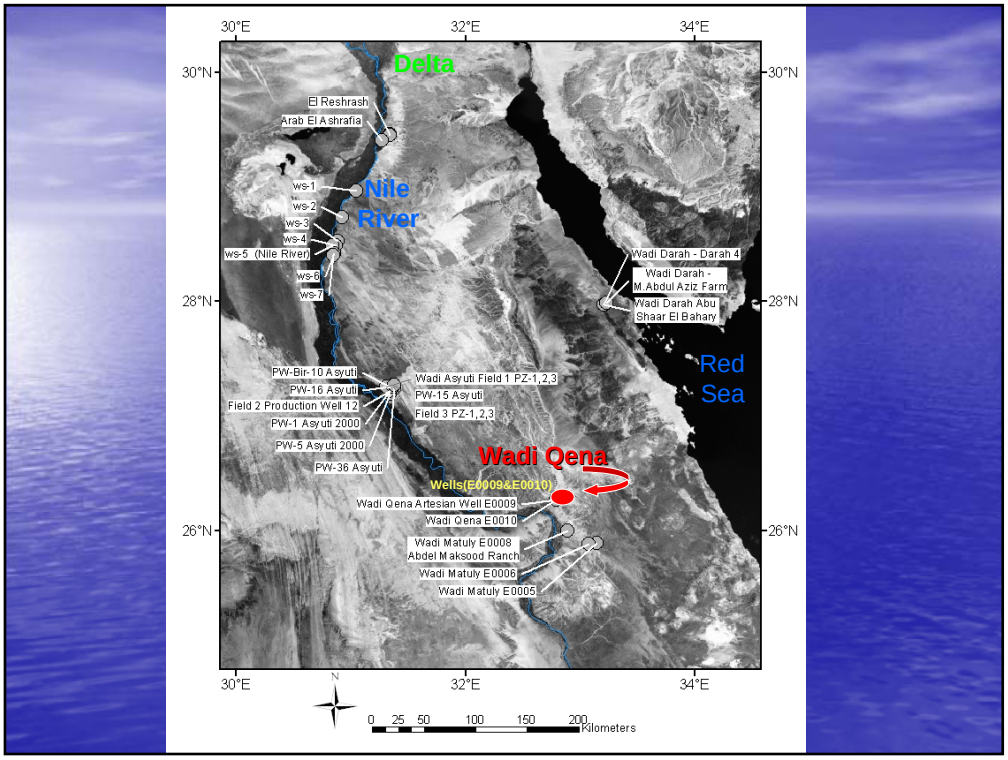

Figure (4) The image of the study area (Wadi Qena)

طريقة تكاملية بين نظم المعلومات الجغرافية و الاستشعار عن بعد لتمثيل الظروف الهيدروجيولوجية و الهيدروكيميائية لوادى قنا– مصر

يحيى إدريس ، محمود شعبان و محمد راشد

معهد بحوث المياه الجوفية – المركز القومي لبحوث المياه – القاهرة – مصر

تعتبر منطقة الدراسة إحدى مناطق الحواف الملاصقة لوادى النيل والتى تعد من المناطق الواعدة فى مجال التنمية والاستثمار والتي تساعد على الخروج من الوادي الضيق ومواجهة مشكلة تزايد السكان وإيجاد فرص عمل جديدة.

استخدام التقنية الحديثة يساعد بشكل مؤثر فى إجراء الدراسات وتمثيل النتائج كما يتيح لمتخذي القرار الإلمام بكل الظروف الخاصة بمنطقة الدراسة بشكل ميسر ومحدد.

وفى هذا البحث تم استخدام طريقة تكاملية بين نظم المعلومات الجغرافية والاستشعار عن بعد مع الاستعانة ببعض البيانات الأخرى والمجمعة من الدراسات الحقلية والسابقة في ايجاد تصور للظروف الهيدروجيولوجية والهيدروكيميائية لمنطقة الدراسة.

ويعتمد منهج البحث على إعداد خرائط معلوماتية مختلفة باستخدام نظم المعلومات الجغرافية وأخرى اعتمادا على صور الأقمار الصناعية ثم إعطاء درجة أهمية معينة لكل خريطة معلوماتية.

وفى النهاية يتم تجميع كل الخرائط باستخدام نظم المعلومات الجغرافية لإنتاج خرائط تمثل الظروف الهيدروجيولوجية و الهيدروكيميائية لمنطقة الدراسة لتكون أداة مساعدة إمام متخذي القرار. وهذه الطريقة تناسب معدى النماذج الرياضية لتمثيل الظروف الهيدروجيولوجية والهيدروكيمائية حيث توفر البيانات اللازمة بطريقة يسيرة وسهلة القراءة للنموذج.

الكلمات المفتاحية: نظم المعلومات الجغرافية ، الاستشعار عن بعد، هيدوجيولوجيا، هيدروكيمياء.