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Geospatial Technique Applications in Groundwater Investigation Review Article

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ABSTRACT

Groundwater is one of the most important sources of water that accumulate in the voids of the rocky layers and soils under the surface of the ground from the rainfall and snows falling on the surface of the earth and from running water such as streams, river and lakes it used by humans for drinking, agriculture, industry and solving many environmental problems. Groundwater investigation and exploration is being the urgent work, development in the technology have helped scientists search for a groundwater using technical methods, including remote sensing and geographic information system, and their great role was in detecting variations on the earth's natural surface of geological, geomorphological, hydrological phenomena, vegetation, river distribution and drainage of streams, as well as in determining the natural surface elements in the earth, which contributes to the approval of the possibility of the existence of groundwater by determination of recharge areas and drainage of surface water and more rainwater infiltration areas. The satellite images and digital maps have effectively contributed to the analysis of the earth's surface phenomena such as faults, rock dams, fractures, linear structures, density of the water drainage network, alluvial fan with vegetable cover, these all enable the experts to interpret the earth surface geology, geohydrology and geomorphology phenomena to explore and production of groundwater.

***Keywords*:** groundwater, remote sensing, GIS, hydrology.

INTRODUCTION

Groundwater is one of the most important sources of water stored in the ground, especially in the fine pores found between silt, sand, and grains, forming water layers called aquifers. It is also considered a part of the natural water cycle on the ground, where it seeps into the ground when rain or surface water in rivers moves through the fragments of rocks, soil, or pores between them, and the water table separates the aquifer in different zones.

Aquifers of the groundwater are divided according to the storage method into [1]:

1-Unconfined aquifer: These reservoirs are characterized by the presence of a high-permeable rock layer between the groundwater level of the reservoir and the surface of the earth, where irrigation water can easily permeate it, this reservoir is limited by an impermeable bottom layer (Fig. 1).

2- Semi-confined aquifer: It is characterized by the presence of an upper or lower layer with little permeability so that its presence in this way allows water to leak from it.

3-Confined aquifer: This reservoir is formed when the water-bearing layer is located between two impermeable layers, so that its presence in this way does not allow water to seep into it from above.

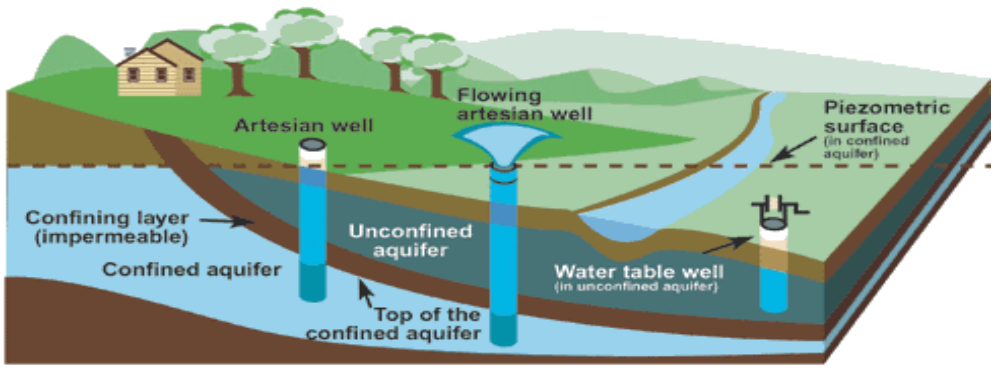

Figure1: The aquifer types

Remote sensing is a science of getting information about a feature or an object on the earth surface without any physical contact with that feature or object by measuring the electromagnetic radiation reflected or emitted from earth surface which are picked by the particular sensors to recognized and grouped these objects by class or type of materials and spatial distribution. Remote sensing is observing wide areas at narrow temporal and spatial occurrence. It has many applications in geology, geomorphology, hydrological conditions and modelling, soil states, vegetation cover, and environmental problems like drought, climate changes and earthquakes.

Remote sensing and GIS and their role in groundwater exploration

Remote sensing techniques and geographic information systems (GIS) are the most important modern scientific techniques produced by the information revolution and space science. They have been employed during the past three decades with high efficiency in the field of studying natural resources, including water resources. This requires continuity, monitoring, and evaluation, and perhaps space data is the best of these means.

The geographic information system (GIS) is a computer system comprising a set of software packages characterized by their ability to enter, store, restore, process and display spatial data for part of the earth's surface [2]. In geographic systems, the studied goal is linked to descriptive or numerical information spatially. GIS technology is integrated with remote sensing technology (as a data source) in the studying and extracting useful results in many areas related to the environmental and natural resources, including the groundwater studies and exploration. The geographic information system (GIS) has a special ability to link and analyze several layers of spatial data and create maps that represent the results of that analysis.

Remote sensing and groundwater

Since groundwater cannot be monitored directly by electromagnetic rays, because it does not exist as a direct target on the surface of the earth or close to it in a way that can emit or reflect electromagnetic radiation, so it is necessary to monitor indicators, evidence the presence of groundwater in a place through the qualities, characteristics and geological structures or the geomorphological nature of the study area by remote sensing visuals data image. Therefore, the ultimate goal of any study to monitor the indicators of the presence of groundwater using remote sensing technology is to produce practical reports or maps or both to reflect the best and most accurate possibilities suitable for groundwater paths and the possibilities of their accumulations. This is done by studying their main elements and factors that determine their characteristics, and the preference of those paths and groundwater aquifers.

The most important of the elements that determine characteristics and the preference of groundwater aquifers are [3]:

1- Recharge area for groundwater.

2- Groundwater discharge areas.

3. Exploratory sites where hydrological conditions are suitable for the possible accumulation and storage of groundwater.

4- Studying the movement or flow of groundwater and surface water and determining their directions. Surface and Ground Water Flow.

5- Identify areas with high or low filtration or leakage

6- Investigating the aquifers that carry groundwater or promise the presence of water in them.

The study of the previous elements using remote sensing technology is carried out by monitoring some geological structures and geomorphological forms that are significant and indicative of the presence of groundwater in the study area.

The most important of these guides and indicators:

1- Faults

A fault is defined as a fracture of the rocks of the earth's crust accompanied by a displacement of rock blocks on the surface of the fracture, where it plays an important role in determining the direction of groundwater [4] (Fig.2). They also act as barriers that prevent the spread of groundwater, as they collect near or along them, in addition they are weak areas in the rocks, which facilitates the process of vertical groundwater movement (filtration) or horizontal flow (flow) through them.

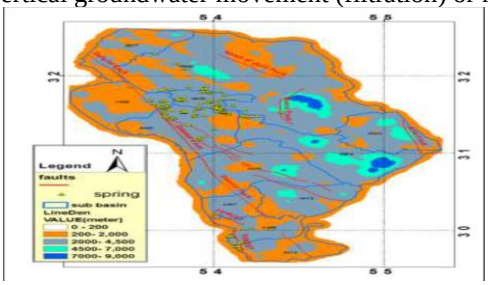

Figure .2 map shows the faults

2- Dikes

It acts as underground dams and trap groundwater causes to the accumulation.

3- Lineaments and fractures

As the relationship between linear structures and the presence of groundwater depends on the porosity of porosity rocks and the density of fractures that gain permeability rocks, which makes them highly efficient to collect surface water, and leakage into underground reservoirs[5], where hydrological studies of remote sensing proved that increasing the density of cracks,

fractures, and weak places in the earth's crust which forms the linear structures (Fig.3) can be relied upon It, should identify sites that are characterized by high permeability that help rocks to enrapt and collect groundwater.

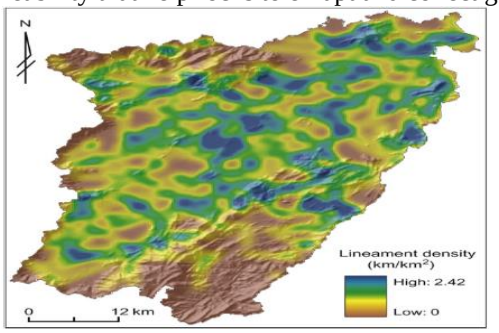

Figure .3 map shows lineaments density

4- Drainage system network

Main Channels are closely related to the main faults and fractures (Fig. 4), and their directions are largely determined by the direction of faults and fractures. Thus, these channels are evidence of faults; on the one hand, they are where water infiltrates into the ground [6].

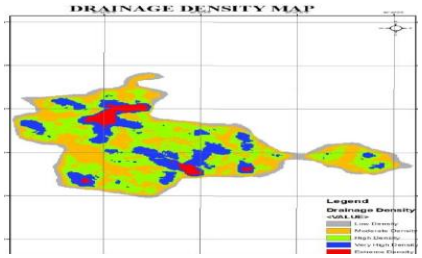

Figure .4 map reveals drainage density

5- Alluvial fans

The upper parts of the fan are coarse-grained, followed by fine sediment at the bottom (Fig.5), so the flood fan heads represent good areas for groundwater production [7].

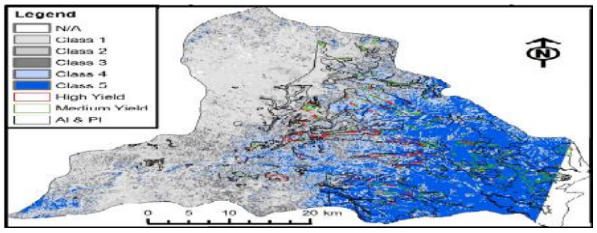

Figure 5. map shows distribution of alluvial fan

6- The valleys or Paleo- drainage stream system:

They were formed in the past in rainy periods, were buried with sediments of different sizes of granules so they are characterized by good permeability and porosity which facilitate the movement and filtration of water into the ground, these valleys were formed in open sedimentary areas or even buried with sand dunes which satellites able to recognized it.

7- Floodplain deposits

They were formed as a result of the accumulation of silt sediments (loam) over the bottoms of the valleys that the rivers have expanded, which are characterized by a low degree of slope. These sediments represent areas with high filtration due to the formation of their deposits of different sizes of grains at the bottom of the fan and therefore have good permeability and porosity.

8- Land cover

Its density in certain areas is evidence of the high water table of the underground [8], and the extension of vegetation cover (Fig .6) in succession in a dense line indicates the presence of faults, especially at the bottom of valleys.

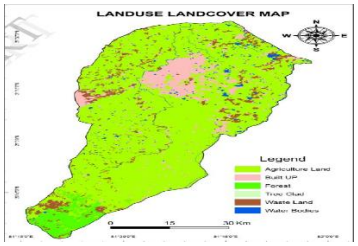

Figure .6 map reveals land cover classes

Groundwater exploration analysis methods and interpretation of visual remote sensing maps have three main aspects:

1-Geological analysis and interpretation

This means the study of geological structures and their relations with groundwater, such as the study of lineaments in terms of their numerical density, directions, intersection[9], distribution and nature(Fig.7). This helps to achieve the hydrological characteristics of the study area as well as to find faults, dikes, slopes and direction of layers. Dip, direction, and geological structures with direct and indirect significance of groundwater occurrence.

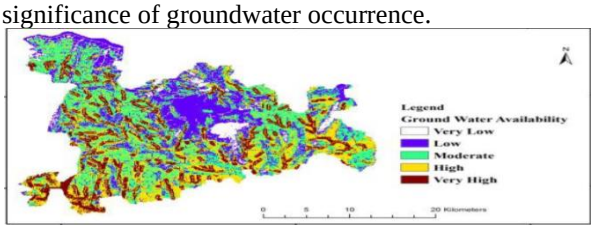

Figure.7 map shows areas of different groundwater potential.

2- Hydrogeological analysis and interpretation

In this aspect, the direction of surface water runoff and infiltration water flow from recharge sites to storage sites clarified in order to determine the appropriate sites for the presence of groundwater and the appropriate sites for the construction of dams to recharge groundwater, in addition to dig wells and observe the relationship between geological structures such as faults and major fractures with the direction of streams and main channels, and river erosion.

3- Hydrogeomorphological analysis and interpretation

It includes the study of various geomorphological phenomena and their relations to surface and groundwater hydrology [10]. These phenomena are the waterways network, drainage system network and the surface forms related to groundwater, such as flood fans, alluvial fans and valley alluvium sediments. Extract a map of the drainage network of the basins of the study area to conduct hydro morphometric study of the basins through ordinary remote sensing (image) or digital elevation model (DEM) image such as the identification of basin boundaries, watershed and tilt slope , catchments and making various measurements of morphometric variables of the main basins such as the area of the basins, the boundaries of the basin, the lengths of the main and sub-streams,, the bifurcation ratio, the percentage of molting, the density of drainage and the frequency of the streams, then assets quantitatively in order to analyze their hydrology and the relationship with the structures geology that exists and is previously studied to know and determine the method of groundwater recharge.

Conclusion

Groundwater is one most important sources of the water, it is being used for drinking, agriculture, industry and for solution many environmental problems. Its demands are increasing nowadays, so it is urgent to apply new innovation tool to explore groundwater which is being important issues. As the technology advanced remote sensing and geographic information system (GIS) aroused facilitate to deal effectively with earth surface natural elements such as water recharge areas and surface water drainage, the more rainwater infiltration areas. Satellite images and GIS maps help in the processing of the earth's surface phenomena such as faults, rock dams, fractures, linear structures, the density of the water drainage network, alluvial fans with vegetation cover, all of which contribute to the investigation and finding of more potential groundwater areas in the world. Finally, we deduced that remote sensing techniques and geographic information systems are good tools for groundwater investigations.

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تطبيقات تنقية الجيومكانية في التحري عن المياه الجوفية (مقالة مراجعة)

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الخلاصة

تعتبر المياه الجوفية احد اهم مصادر المياه التي تتجمع في الفراغات الموجودة في الطبقات الصخرية والترب تحت سطح الارض من الامطار والثلوج الساقطة على السطح الارض ومن المياه الجارية كالسيول والانهار والبحيرات , ويستخدم من قبل الانسان لأغراض الشرب والزراعة والصناعة. اصبح التحري والكشف واستخراج المياه الجوفية من الاعمال المهمة . التقدم الحاصل في التكنولوجيا ساعدت العلماء في البحث عن وجود المياه الجوفية امرايسيرا باستخدام الطرق الفنية منها الاستشعار عن البعد ونظم المعلومات الجغرافية ودورهما الكبير في كشف عن التغيرات الموجودة على سطح الارض من الظواهر الجيولوجية والجيومورفولوجية والهيدرولوجية والغطاء النباتي وتوزيع الانهار و تصريف المجاري المائية ,وكذلك في تحديد مظاهر سطح الارض الطبيعية الذي يساهم في اقراراحتمالية وجود المياه الجوفية من مناطق التغذية وتصريف المياه السطحية والمناطق اكثر ترشحا لمياه المطر الى داخل الارض .اسهمت المرئيات الفضائية ونظم معلومات الجغرافية بشكل فعال في تحليل ظواهر سطح الارض مثل الفوالق والسدود الصخرية, والتكسرات والتراكيب الخطية وكثافة شبكة تصريف المياه والمراوح الفيضية ووجود الوديان ومجاري المياه القديمة و ترسبات المياه الفيضية والغطاء النباتي وهذه مكنت المختصين في تفسير الجيولوجيا والجيوهيدرولوجي والهيدرولوجي في والتحري عن المياه الجوفية وبالتالي استخراجها من الارض بالطرق الملائمة.

الكلمات المفتاحية : المياه الجوفية , الاستشعار عن البعد , ***GIS*** , هيدرولوجي .