P- ISSN 1991-8941 E-ISSN 2706-6703 *Journal of University of Anbar for Pure Science (JUAPS)* Open Access
2015,(9) ,(1) :39-45

Hydrogeomorphological Study for Shallow Groundwater Prospecting Within Solani Watershed in Haridwar District, Uttranchal. India

Mufid Saady Alhadithi

Meddle Technical University - Institute of Technical in Anbar

ARTICLE INFO

Received: 19 / 5 /2022
Accepted: 28 / 5 /2022
Available online: 19/7/2022
DOI: 10.37652/juaps.2015.124206

Keywords:
Hydrogeomorphology,
Remote Sensing, GIS,
Solani watershed,
India.

ABSTRACT

Hydrogeomorphological study has been carried out to demarcate shallow groundwater prospecting zones of the Solani watershed in Haridwar district, Uttranchal, India. An integrated geographic database, consisting of spatial and non spatial data, has been generated for the study area using remote sensing and geographical information system (GIS) technique coupled with ground truth investigations. The spatial database layers like hydrogeomorphology, land use/land cover, soil, slope and geology generated from topographic maps and satellite data while the non spatial data is derived primarily from ground checking during field survey and from the available literature. These data have been stored in the GIS databank for digitization, computational purpose and output generation to locate the availability of shallow groundwater in solani watershed for prospecting purposes. The result had been show that the southern part of solani watershed associated with hydrogeomorphological unit of lower piedmont (covering 367 km^2) has very good to excellent categories of prospect zones while the shallow groundwater prospect zones is very poor in the northern part (hilly area) covering about 163$km^2$of the study due to steeply slopes and very high drainage densities which are grouped together as runoff zone in the study area. In the middle part associated with upper piedmont zone, the category of prospecting shallow groundwater is good and covering about 96 km^2 of the area with gentle slope and low drainage density. The present study shows that a spatial technique has been proved to be very efficient in delineation of groundwater prospect zone of the considered area.

Introduction

In recent times, there has been rapid growth in industrialization, population and agricultural activities that has lead to tremendous increase in demand for fresh water [1]. This resulted in creating pressure on the fresh water resources leading to overexploitation, reducing the groundwater level and increasing the scarcity of water. In the study area the principal source of ground water recharge is through rainfall, although the river and streams emerging from Siwalik Hills also form a significant recharge source. These resources under threat due to depleting water table, which is causing land-degradation so exploration of groundwater in this regions is necessary and require use of suitable techniques to give optimum result. The present study is undertaken to delineate the shallow groundwater prospecting zones in the Solani watershed in haridwar district, India using Remote Sensing and Geographical Information System (GIS) techniques. Remote sensing and GIS applications have been used by numerous scientists in mapping of groundwater prospect zones [2], [3], [4] and [5]. A number of studies have also been carried out using remote sensing techniques for geomorphological and geological studies which include the investigations of [6] [7] [8] [9] [10] and [11]. The advent of Remote Sensing has opened up new vistas in geological, geomorphological and structural mapping for

———* Corresponding author at: **Meddle Technical University - Institute of Technical in Anbar**
.E-mail address:

groundwater exploration. The satellite imagery also portrays an unbiased picture of the area providing integrated information on different terrain factors controlling the groundwater regime.

Solani Watershed is a sub watershed of the river Ganges and Ganges is the largest river in India. It is situated between latitudes 29° 49' 00" to 30° 17' 21" North and Longitude 77° 43' 19" to 78° 04' 21" (Fig.1) and it is belongs to state of Uttaranchal in northern part of India.

The main geological formation in the study area is Siwalik rocks and alluvial deposits. The alluvial fan deposits of recent age (referred to as the Piedmont zone) are made up of assorted sands and gravels with occasional clays. The belt extends in an elongated manner along the foothill region, roughly in a NW-SE direction. After necessary ground checking and correlation with the existing literature [12] [13] [14], the geologic units were mapped using Arc View 3.3 [15] software to prepare a thematic map for the geology of the area (Fig. 2).

Materials and Methodology

The occurrence and movement of groundwater in an area is controlled by geological and environmental parameters [5] and [16]**.** In this project both satellite as well as extensive field data were used for preparation of various thematic maps. As far as satellite data is concerned Indian Remote Sensing (IRS) LISS III image was used for the interpretation on 1:50,000 scales and analysis. In addition to the satellite imagery, the secondary data which was used also including Survey of India (SOI) topographical maps, and other literatures. The Image processing software ERDAS 9.2 [17], is used to enhance (IRS), LISS III image for interpretation of the hydrogeological features, which mainly include hydrogeomorphology, geology, landuse/ landcover, soils, slope and drainage density. The thematic maps so prepared by interpretation were digitized in Arc View, (version 3.1) platform. This analog to digital conversion was done for overlay analysis of all the thematic maps in order to delineate the groundwater prospect zone of the study area**.**

Result and Discussion

The hydrogeomorphological map of the solani river watershed has been prepared from integrating of the topographic maps, remote sensing data, checking during field survey and available literature. Based on hydrogeomorphological characteristics, the area is classified into four hydrgeomorphic units. The hydrogeomorphic boundaries are digitized on the enhanced image through GIS and used to generate the hydrogeomorphological map as shown in Fig. 3. The hydrogeomorphic units of the area are classified under fluvial origin, denudational origin and structural origin. The aerial coverage of different units and their water prospects are given in table 1. Depending on the hydrogeomorphological map hydroge- omorphological section was also drawn to explains hydrologeomorphological units of the study area extends from north to south of the study area Fig.4.

Topographic information has been collected from the Survey of India (SOI), topographic sheet on a 1:50,000 scales and a Triangulated Irregular Network (TIN) have been generated from topographic contours (20 m interval) and spot elevations. A slope percent map has been generated from the TIN data (Fig.5). It has observed that nearly 40% of the total area in the southern part which represent the hydrogeomrphological units of Lower Piedmont has slopes of 0–1% and the steep slope (more than 23%) are found in the northern and northeastern parts of the Upper Piedmont. Based on the slope percent map most promising area for groundwater development is the lower piedmont zone in the southern part of solani watershed.

The drainage network of the solani watershed was delineated using satellite data IRS-1D (LISS-III data) and Survey of India toposheets as reference. The morph metric analysis of the watershed has been carried out using ERDAS Imagine software 9.2 [17], and Arc view GIS 3.3 version [15]. The drainage network exhibits dendritic on higher slopes and subdendritic on gentle slopes which indicate that homogeneous materials are covering the area controlled by minor structures. The drainage density of the study area varies between 0 to 1.4 km/km^2 (Fig.6) which observed that area impermeable materials in the plain area and structurally controlled in the hilly area. High drainage density leads

to increased runoff and reduced infiltration of groundwater and as a result, groundwater is low in these areas. Accordingly the southern part of study area has excellent groundwater prospect while the northern part (Hilly area) is very poor.

Loam, sandy loam, Loamy sand and Sandy are the main soil types found in the solani river watershed (Fig.7). Mainly upper hilly area contain sandy loam while lower flat terrain dominated by loam and loamy sand. Sandy soil is the most promising area for shallow groundwater prospecting because of the sandy soil is a high permeability and help on water percolating into the ground

There are major six lands use types are found in the watershed (Fig. 8). These are dense forest, sparse forest, scrub, agriculture, fallow land, agriculture and seasonal river.

Forests cover around 27 % of the total area especially in hilly part of the basin and more than 36 % of the land belongs to agriculture in lower flat terrain. Wheat is grown as a seasonal crop during rainy season while mango orchards are prominent as perennial crop. Sugarcane cultivation is prominent in southern end of the watershed. In general, cultivated (agriculture) land is the most promising area for groundwater development because of this type of land uses reduces the discharge of water and helps water seeping into the ground.

Depending on above discussion the entire area is qualitatively divided into four different groundwater prospecting zones namely excellent, very good, good and poor to very poor. These zones are shown in table 2. It has been observed that the groundwater prospective in the northern part of the study area represented by hilly area and covering about 163 km^2, is poor to very poor, due to very steep slopes and very high drainage densities which are resulting in low infiltration and high runoff. In the middle part associated with Upper Piedmont unit (covering 96 km^2 of the area) the groundwater prospecting categories is good because of gentle slope and low drainage density. In the southern part which represent the Lower Piedmont hydrogeomorphic unit about 125 km^2 of area has very good and 242 km^2 has excellent groundwater potential due to gentle slope and very low drainage density.

Conclusions

Hydrogeomorphological study has been carried out in this study to demarcate the groundwater prospecting zones of solani watershed using remote sensing and GIS technique. This study has brought out the importance of hydrogeomorphological studies indicating the preliminary shallow groundwater prospecting zones in the area of study. Broadly, the delineation of hydrogeomorphic features; slope, landuse and drainage density maps help in identifying groundwater prospecting zones of the considered area. The results indicate that the southern part of the study area has a very good groundwater prospect for meeting the demand of water for irrigation and domestic purposes whereas the steeply sloping area in the northern part, having high relief, has a poor groundwater potential. The resulting delineation of groundwater prospect will serve the twin benefit of helping the field geologists to quickly identify the prospective groundwater zones for conducting site specific investigations and select the sites for planning recharge structures to improve sustainability of drinking water sources, wherever required.

References

1- Raju, N. Janardhana (2007): Hydro geochemical parameters for assessment of groundwater quality in the upper Gunjanaeru river watershed, Cuddapah district, Andhra Pradesh, South India. Environmental Geology 52, pp.1067-1074.

2- Srivastava, P.K and Bhattacharya A. K.,(2006): Groundwater assessment through an integrated approach using remote sensing, GIS and resistivity techniques: a case study from a hard rock terrain. Int. Journal of Remote Sensing Vol. 27, No. 20, pp. 4599-4620.

3- Vijith, H. (2007): Groundwater potential in the hard rock terrain of Western Ghats: a case study from Kottayam district, Kerala using RESOURCESAT-1 (IRS-P6) data and GIS techniques, Journal of Indian Society of Remote Sensing, Vol. 35, No. 2

4- Prasad, R. K., Mondal, N. C., Banerjee, Pallavi, Nandakumar, M. V. and Singh, V. S., (2008): Deciphering potential groundwater zone in hard rock through the application of GIS, Environmental geology, 55/3, pp-467-475.

5- Thomasa, B. C, Kuriakoseb, S.L. Jayadev, S.K., (2009): A method for groundwater prospect zonation in data poor areas using remote sensing and GIS: a case study in Kalikavu Panchayath of Malappuram district, Kerala, India, Vol-2/2.

6- Subramanyan, S.K. , K. Keshavasamy, K. Hanumantha Rao, and S.K Bhan, (1988): Coastal geomorphology and sediment distribution mapping using Landsat TM Digital data- A case study in coastal area of parts of Orissa, India, Journal of the Indian society of Remote Sensing, vol. 16 no. 3, pp. 1-6,.

7- J. Krishnamurthy, N . Venkataesa Kumar, V. Jayraman, and M. Manivel, (1996): An approach to demarcate groundwater potential zones through remote sensing and GIS, International Journal of Remote Sensing, vol.17, no.10, pp. 1867-1884,

8- Palanivel, S. A . Ganesh and J. Vasantha Kumaran, (1996): Geohydrological evaluation upper Agniar and Vellar Basins, Tamilnadu: An integrated approach using remote sensing, geophysical and well inventory data, Journal of the Indian society of Remote Sensing, vol. 24, no.3, pp. 153-168,.

9- Das, S. S. C Behera, A Kar, P Narendra, S Guha., (1997): Hydrogeomorphological mapping in ground water exploration using remotely sensed data — a case study in keonjhar district, orissa Journal of The Indian Society of Remote Sensing , vol. 25, no. 4, pp. 247-259, 1997

10 - Saraf, A.K. and P.R. Chaudhary, (1998): Integrated remote sensing and GIS for groundwater exploration and identification of artificial recharges sites, International Journal of Remote Sensing, vol. 19, no.10, pp. 1825-1841,.

11- Jasrotia, A.S., Ajay Kumar, Mohd Aasim (2012):Morphometric analysis and hydrogeomorphology for delineating groundwater potential zones of Western Doon Valley, Uttarakhand, India International journal of geomatics and geosciences Vol. 2, No. 4, pp 1079- 1096.

12- Pandey, M. P., Raghava Rao, K. V. and Raju, T. S. (1963): Groundwater resources of Tarai-Bhabhar belts and intermountain Doon Valley of Western UTTAR PRADESH. Report Prepared For MFAA. 253p.

13- Sharma, D and Jugran, D. K. (1992): Hydromorphogeological studies around Pinjaur-Kala Amb area, Ambala District (Haryana), and Sirmur District (Himachal Pradesh), Journal of the Indian Society of Remote Sensing, Vol. 20, No. 4, pp. 281-286.

14- Rao, M. S., Kumar, B., Nachiappan R. m. P, Jagmohan. (2000): Identification of aquifer recharges sources and zones in parts of Ganga-Yamuna Doab using environmental Isotopes. ICIWRM-2000 Proceedings of International Conference on Integrated Water Resources Management for Sustainable Development, 2000, New Delhi India, pp. 271-281.

15- ESRI, Arc View GIS, (1996): The Geographic Information System for Everyone Environmental System Research Institute, Redlands, CA, 340 pp.

16- Jaiswal, R.K., Mukherjee, S., Krishnamurthy, J., and Saxena, R., (2003): Role of remote sensing and GIS techniques for generation of groundwater prospect zones towards rural development: an approach, International Journal of Remote Sensing, 24 (5), pp. 993-1008.

17- ERDAS. , ERDAS Imagine, (1997): Tour Guides, ERDAS, Inc., Atlanta, USA, 454pp.

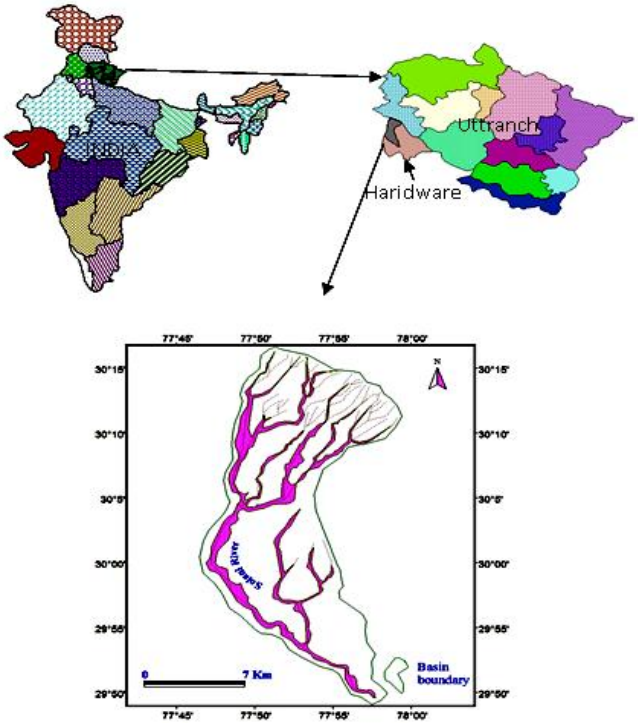

Fig.1: Location map of the study area

P- ISSN 1991-8941 E-ISSN 2706-6703 *Journal of University of Anbar for Pure Science (JUAPS)* Open Access
2015,(9) ,(1) :39-45

Table 1: Hydrogeomorphological unit based on groundwater prospects zones

Unit	Origin	Characteristics	Hydrological Properties (Ground water prospects)
Flood plain	Fluvial	Alluvium-Nearly level surface along the river courses with sand, silt, clay and gravel	Recharge-Cum Discharge (Excellent to very good)
Younger Terrace	Fluvial	Alluvium- Gentle slopes with more vegetation and consists of sand, silt, clay and gravel	Recharge-Cum Discharge (Excellent to very good)
Older Terrace	Fluvial	Alluvium- Away from hills with sand, silt, clay and gravel	Recharge Zone (Very good to good)
Lower Piedmont	Denudational origin	Gravel- Gentle to Moderate slope with admixture of gravel, sand, silt and clay	Recharge Zone (Very good to good)
Upper Piedmont	Denudational origin	Gravel- Moderate to steep slope with admixture of gravel, sand, silt and clay	Recharge Zone (Good to moderate)
Siwalik Hill	Structural origin	Inter bedded mudstones, sandstones, conglomerates and subordinate marls	Recharge-Cum Runoff Zone (Poor to negligible)

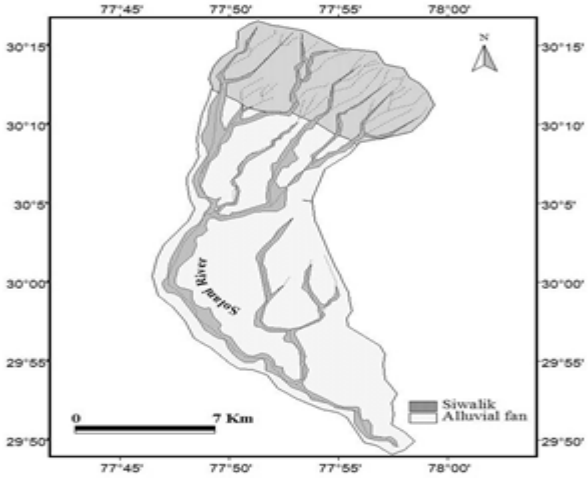

Fig.2: Geological map

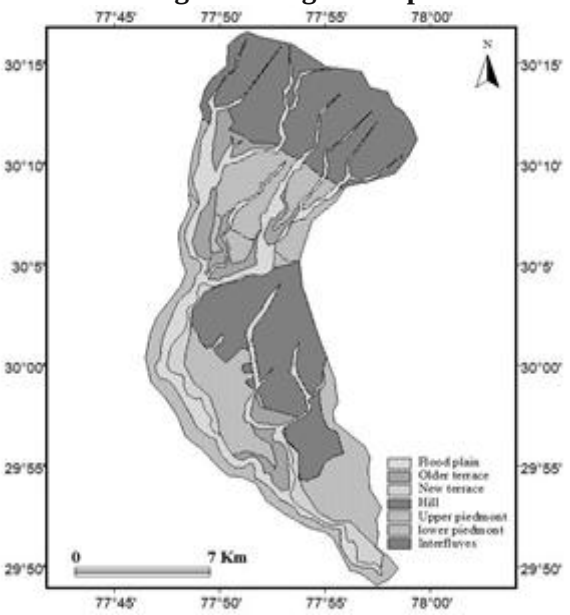

Fig. 3: Hydrogeomorphological map

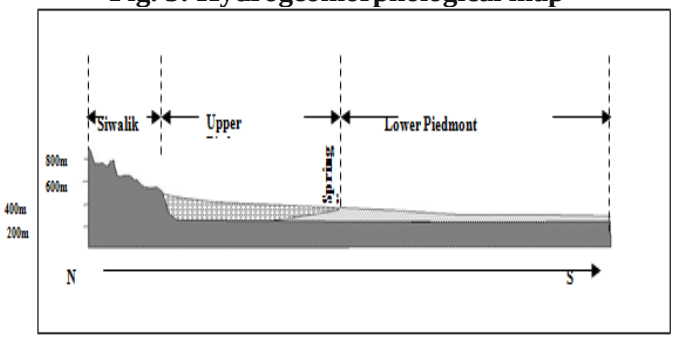

Fig 4: Hydrogeomorphological section of the Solani river watershed

P- ISSN 1991-8941 E-ISSN 2706-6703 *Journal of University of Anbar for Pure Science (JUAPS)* Open Access
2015,(9) ,(1) :39-45

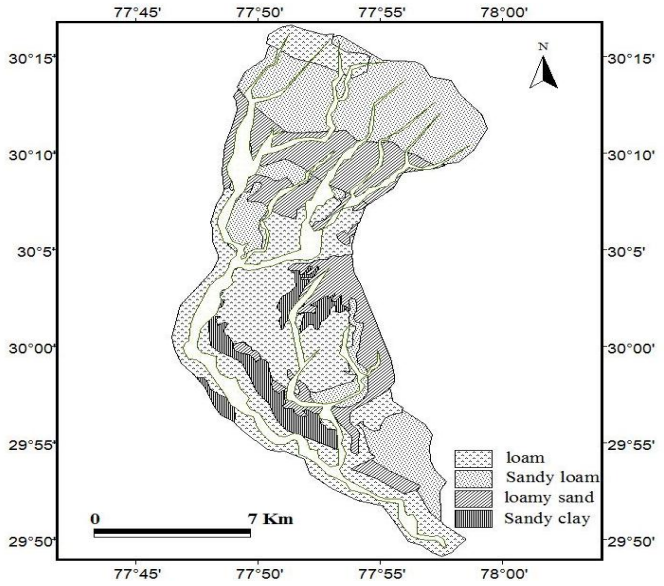

Fig.5: Slope map

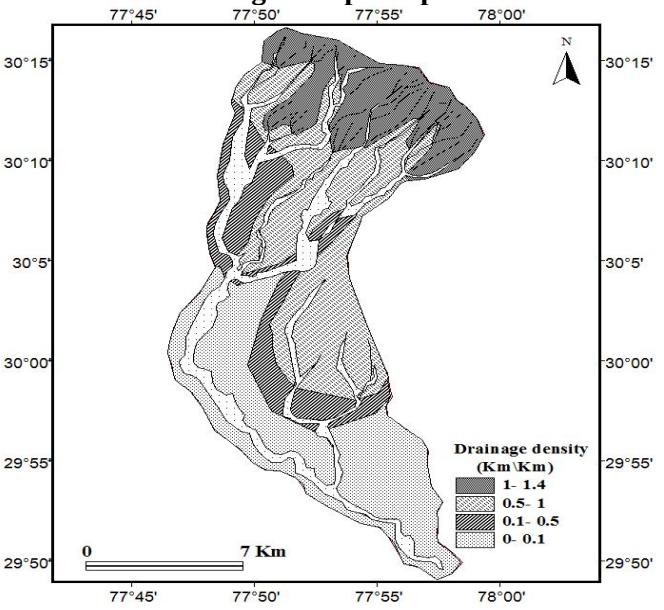

Fig.6: Drainage density map

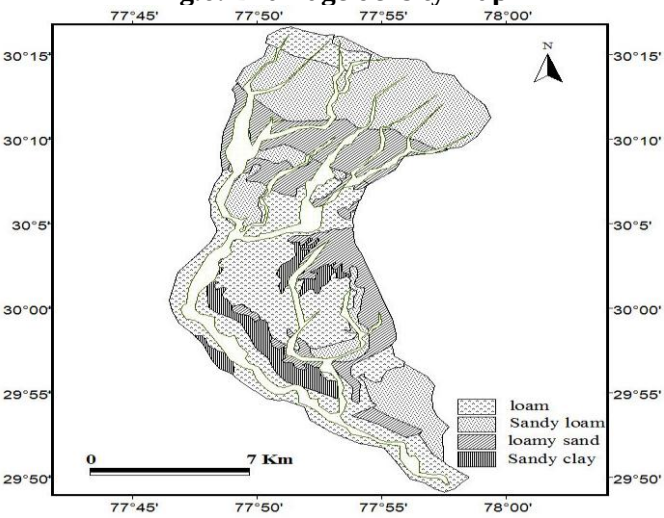

Fig.7: Soil map

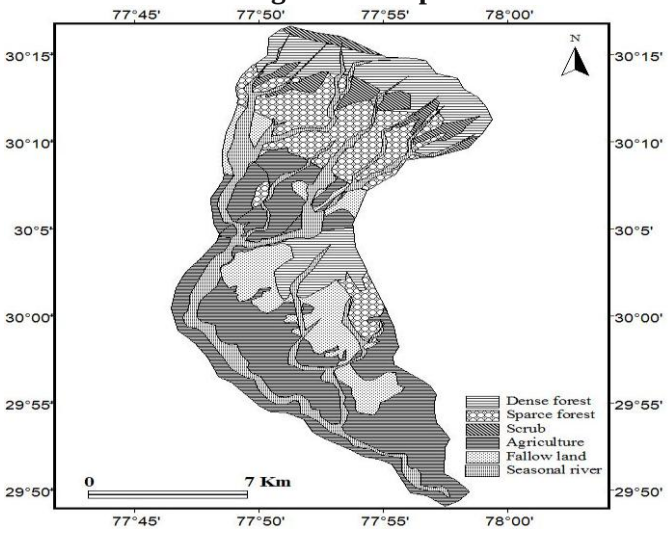

Fig.8: Landuse map

Table 2: Ground water prospect zones in Solni watershed

Groundwater Prospect zones	Hydrogeomorphological Features	Slope percent	Drainage density	Landuse	Soil texture
Excellent	Flod plain Younger Terrace Old terrace	0-1	0-0.1	Agriculture & Seasonal river	loam
Very Good	Lower piedmont	1-7	0.1-0.5	Flow land	Sandy clay
Good	Upper piedmont	7-11	0.5-1	Sparce forest	Loamy sand
Poor to very poor	Hilly area	>11	1-1.4	Scurb & dense forest	Sandy loam

P- ISSN 1991-8941 E-ISSN 2706-6703 *Journal of University of Anbar for Pure Science (JUAPS)* Open Access
2015,(9) ,(1) :39-45

دراسه هيدروجيومورفولوجية للتنقيب عن المياه الجوفية الضحلة في حوض سولاني في مقاطعة هريدوار في الهند

د.مفيد سعدي الحديثي

E.mail:

الخلاصة:

تم تنفيذ الدراسة الهيدروجيومورفولوجية لغرض تحديد مناطق محتمله للتنقيب عن المياه الجوفية الضحلة في حوض سولاني في مقاطعة هريدوار، في الهند. تم إنشاء قاعدة بيانات جغرافيه متكاملة تتألف من البيانات المكانية والغير مكانيه لمنطقة الدراسة باستخدام تقنية الاستشعار عن بعد ونظم المعلومات الجغرافية إلى جانب الدراسة الحقلية الحقيقة من أرض الواقع. أنشئت البيانات المكانية مثل خرائط الجيومورفولوجيا المائية، واستخدام الأراضي، واستخدامات التربة، والانحدار، والجيولوجيا باستخدام الخرائط الطوبوغرافيه وبيانات التحسس النائي أما البيانات الغير مكانيه فأنها اشتقت من خلال فحص الأرض والمسح الميداني ومن الدراسات المتوفرة لمنطقة الدراسة. وقد تم تخزين هذه البيانات في بنك معلومات نظم المعلومات الجغرافية لتحويلها إلى بيانات رقميه وتحليلها لتحديد مناطق توفر المياه الجوفية في مستجمعات مياه سولاني لغرض التنقيب عنها. وقد أظهرت الدراسة أن الجزء الجنوبي من حوض تجمعات المياه في منطقة الدراسة والتي تمثل الوحدة الهيدروجيولوجيه البيدمونت السفلي هي جيدة جدا إلى ممتازة بسبب الميلان القليل وكثافة التصريف الواطئة والتي تغطي مساحه تقدر ب٣٦٧ كم مربع بينما في الجزء الشمالي لمنطقة الدراسة (المنطقة المرتفعة) والتي تغطي مساحه تقدر بحوالي ١٣٦ كم مربع هي فقيرة جدا بسبب الميلان العالي وكثافة التصريف العالية والتي ينتج عنها جريان عالي للمياه وعدم ترشيح المياه الى باطن الأرض أما في المنطقة الوسطى لمنطقة الدراسة والتي تمثل الوحدة الهيدرجيومورفولوجيه البيدمونت العلوي والتي تغطي حوالي ٩٦ كم مربع تكون فيها فئة التنقيب عن المياه الجوفية جيده بسبب الميلان القليل وكثافة التصريف القليل. أن الدراسة الحالية أثبتت أن التقنيات المكانية (الاستشعار عن بعد ونظم المعلومات الجغرافية) فعالة جدا في تحديد منطقة احتمالية تواجد المياه الجوفية ضمن المناطق التي تتشابه جيولوجيا مع منطقة الدراسة.