RESEARCH PAPER | Geology | Volume : 6 | Issue : 2 | FEBRUARY 2016 | ISSN - 2249-555X

Application of Geoinformatics for Groundwater Prospects Zones- A Case Study for Vaniyar Sub Basin of Ponnaiyar River in South India

KEYWORDS: Prospect zone, lineament, GIS, Slope, Raster map

S.Satheeshkumar
Research scholar, Hydrogeology Lab, Department of Geology, Periyar University, Salem-11, Tamil Nadu

S. Venkateswaran
Professor, Hydrogeology Lab, Department of Geology, Periyar University, Salem-11, Tamil Nadu

R.Kannan
Research scholar, Hydrogeology Lab, Department of Geology, Periyar University, Salem-11, Tamil Nadu

ABSTRACT *Groundwater prospect zones were delineated through the integration of the reclassified raster map layers of geomorphology, lineament and lineament density, drainage, slope percent, geology and soil type using the weighted overlay analysis in ArcGIS software. The spatial and non-spatial data on various terrain features have been generated using geospatial imageries, SOI toposheets, etc. an attempt to have been delineate groundwater Prospect zones were grouped in the study area into five classes and their distribution are very good, good, moderate, poor and very poor. The study area is underlain by massive Charnockite and followed by Epidote-Hornblende-Gneisses gneiss type of rock formations. Slope map shows steeper slopes in the south eastern and western part of the study area. Dendritic to sub-dendritic drainage pattern is dominant in the area, is often controlled by lineaments and fault zones. The upper, middle and downstream of the basins have been identified as prospect zones for groundwater exploration. The regions of lineaments and lineaments intersect point proved for groundwater potential zones. Major portion of the study area falls in the category 'moderate' followed by 'good'. The study results have been verified with field validation, The Groundwater prospect map of Vaniyar Sub Basin will be served as a base for further exploration using geophysical methods to locate potential well sites for the implementation of groundwater supply schemes.*

INTRODUCTION

Groundwater is an one of the important source for human use, it does not always occur in sufficient quantity where it is most needed. In recent decades, development of groundwater for various purposes such as drinking, irrigation and industrial has remarkably increased. The uncritical development of groundwater often results in the decline of groundwater table and drying up of wells in many places (Raju, N. Janardhana, 2007). The groundwater occurrence and movement are directly or indirectly controlled by terrain characteristics. Groundwater occurrence being a subsurface phenomenon, its identification is indirectly based on the analysis of some directly observable features. The interpretation of satellite data in conjunction with sufficient ground information makes it possible to delineate various terrain features such as geomorphology, geological structures, etc, Groundwater development requires the analysis of extensive spatial characteristics such as geomorphology, geology, soil, drainage density, slope, lineament density, etc. Geographic Information System (GIS) offers for handling and analyzing spatial data including the delineation of groundwater prospect zones (Jaiswal, R.K, 2003; Prasad , et. al., 2008, Vijith, H., 2007, Srivastava, et. al., 2006) Vijay Prabhu et al (2015). Tamilnadu water supply and drainage (TWAD) has providing safe drinking water and sanitation facilities in the rural sector on a sustainable basis through a cost sharing mode by the beneficiaries. In this case, an investigation has been carried out to delineate the groundwater prospect zones in vaniyar sub basin using the application of Remote Sensing.

STUDY AREA

The study area located in Salem and Dharmapuri districts of Tamil Nadu. The base map have been prepared from toposheets Nos. 57L/4, 8, 58, I/1, and 5 of 1:50,000 Scale. The ephemeral stream Vaniyar has its source along the northern slopes of Shervorayan hills takes a course along the northeast in the valley and emerges out as the main artery of Dharmapuri district with northeast gradient and small portion of catchments area falls in Salem district. The Vaniyar sub-basin covers 128 total revenue villages. The study area is mainly composed of Charnockite and Epidote-Hornblende-Gneisses.

MATERIALS AND METHODS

The multiple parameter analysis (MPA) for delineating the groundwater potential zones in the study area has been done by GIS-based Analytical hierarchical process (AHP) technique. In this study area region, six spatial parameters such as Lithology, Geomorphology, Slope, Drainage density, Lineament density and soil are analyzed by AHP approach including geometric mean and normalized weight calculation to explore the potential prospect zone for groundwater exploration.

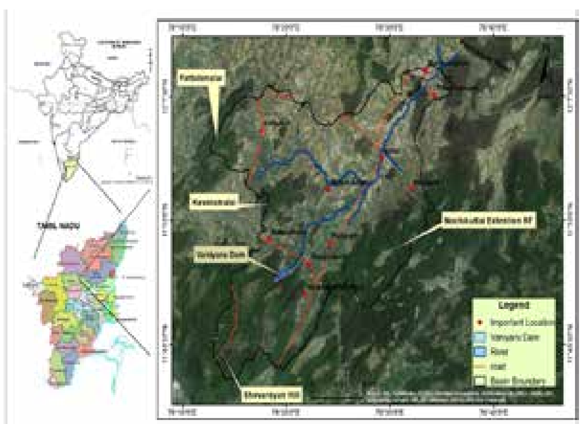

Figure 1: Base Map of the study area

Volume : 6 | Issue : 2 | FEBRUARY 2016 | ISSN - 2249-555X

RESULTS AND DISCUSSIONS

Analytical Hierarcahical Process (AHP) is used to demarcate the potential groundwater zones and this technique was proposed by Saaty (1980). The AHP method allows assessing the geometric mean followed by allotting a normalized weight to various parameters for finalizing the decision process. In this study, the AHP pair-wise matrix was developed by input values of scale weights of parameters based on direct or indirect relationship if a parameter has direct influence towards groundwater potential, then the score was assigned as 1 and for indirect influence the assigned score is 0.5.

Ranking for Various Parameters

Raster map processed and analysed in overlay and ranking is given to evaluate suitable groundwater prospect zone. The movement of groundwater in this area is governed by several layers, such as lithology, geomorphology, lineament density, soil, drainage density, slope and interrelationship between these layers (Jaiswal et. al., 2003).

Geomorphology

The geomorphological characteristics of landform play an important vital role for flow direction groundwater and distribution in the study area. Several types of geomorphic units are identified in the study area for groundwater prospect zone. Valley fill and valley and those are the best landform for high groundwater prospect zone in the region of sub basin.

TABLE-1
WEIGHTAGE OVERLAY ANALYSIS

Thematic layers	Weightage (%influence)	Individual feature	Feature score
Geomorphology	25	Denuda-tional hill	1
Pediment- inselberg complex		Pediment buried	1
Pediplain weathered		2	
Residual hill		3	
		1	
Structural hill (large)		2	
Structural hill (small)		2	
Waterbody mask		5	
Lithology	10	Granite	4
Pink migmatite		Granitoid gneiss	5
Purple conglomerate sandstone		2	
Shales with bands of limestone		4	
		1	
Syenite		2	
Soil	10	Alfisols	3
Hillsols		Entisols	5
		1	
Inceptisols		2	
Resereve forest		2	
Vertisols		1	
Slope	15	Nearly level	5
Moderate		Gentle	4
		3	
Steep		2	
Very steep		1	
Drainage density	20	0-0.50	1
1.28-2.23		0.50-1.28	2
		3	
2.23-3.11		4	
3.11-4.4		5	
Lineaments density	20	0-0.45	1
0.75-1.07		0.45-0.75	2
		3	
1.07-1.52		4	
1.52-1.84		5	

Drainage Density

The drainage density map shows the flow of water in the study area. Density which is indicates closeness between channels as well as the nature of surface material. More the density high would be the runoff. To visualize the areas of different drainage Density it is group in to 5 classes such as very low drainage density (13.19 km^2), low drainage density, medium drainage density and high drainage density (209.23 km^2) are derived based on spatial density analysis of drainage network. The suitability of groundwater potential zones is indirectly related to drainage density because of its relation with surface runoff and permeability.

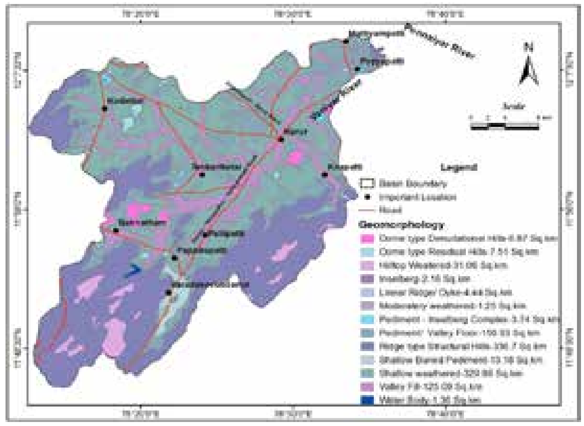

Figure 2: Geomorphology Map of the study area

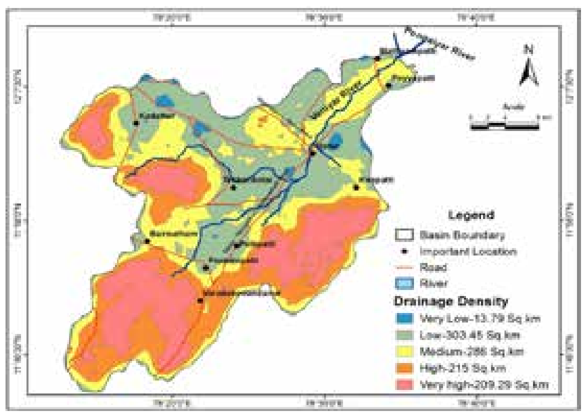

Figure 3: Drainage Density of the study area

Slope

The Slope of an area is one of the governing factors of groundwater recharge. It influences surface and subsurface flow of rain water and its recharge to the groundwater reservoir that become good prospect zone. Gentle slope of an area runs more time to infiltrate the rainwater to aquifer zone where as high slope allows reduced time resulting low infiltration to underlying groundwater. The slope map of the study area has been prepared from LANDSAT 30m. The slope of the study area mainly varies between 0-5 percent. Class having less value is assigned higher rank due to almost flat terrain while the class having maximum value is categorized as lower rank due to relatively high run-off. Slope plays an important role in the groundwater occurrence as infiltration is inversely related to slope (Mondal

Volume : 6 | Issue : 2 | FEBRUARY 2016 | ISSN - 2249-555X

et al.2009). The dominance of the lower slope classes is a favourable feature for groundwater recharge and its potential depends on underlying lithology as well as geomorphology. A break in the slope (i.e. steep slope followed by gentle slope) generally promotes an appreciable groundwater infiltration (Saraf et al., 1998).

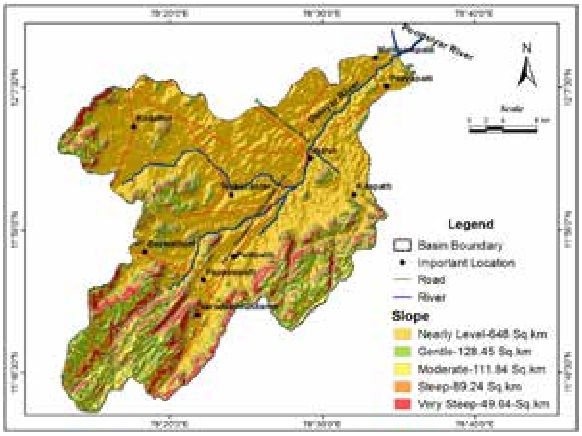

Figure 4: Slope Map of the study area

Lineaments density

Lineament density is one of the important thematic maps prepared from the lineaments, which are critically used in groundwater studies related to hard rock terrain (Krishnamurthy et al. 1996).. Lineaments, faults and fractures are the important linear structures for increasing the permeability of the bed rock in the study area as it indirectly provides the information about the movement and storage of groundwater. The lineament density zone was classified into three classes which are very high lineament density zone (2 to 4 km with in a grid), medium density lineament zone (1 to 2 km with in a grid) and low density lineament zone(< 1km with in a grid) (Fig.5.).

The high density lineament occupied 123 km^2 area , the medium density lineament occupied 295 km^2 and the low density lineament occupied 395.5 km^2 area. The high density lineament occupied as patches throughout the study area, the other two lineament density types are well distributed throughout the study area.

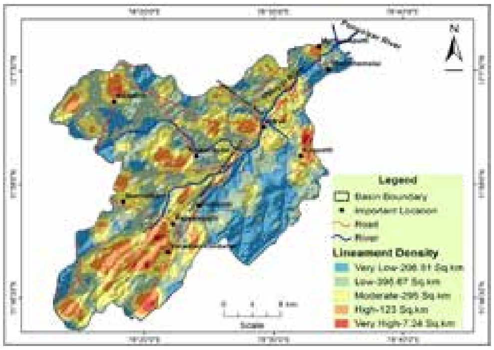

Figure 5: Lineament Density of the study area

Soil

The soil for the study area reveals six main soil categories namely Alfisols, Entisols, Inceptisols, Vertisols, hill soil and Reserve forest. Rank of soil has been assigned on the basis of their infiltration rate. A suborder of the soil order Alfisol; brown soil formed in audic moisture regime and in a mesic or warmer temperature regime. A suborder of the soil order Alfisol categories are covered an area in 340.37 Km^2. A suborder of the soil order Entisol, characterized by a texture of loamy fine sand or coarser sand, and by a coarse fragment content of less than 35

Inceptisols are form by quickly through alteration of parent material. They are more developed than entisols. They have no accumulation of clays, iron oxide, aluminium oxide or organic matter. They have an ochric horizon and a cambic subsurface horizon. Vertisols are churning heavy clay soils with a high proportion of swelling clays from deep wide cracks from the surface downward when they dry out, which happens in most years. Vertisols are categories are covered an area in 205 Km^2.A reserve forest is a specific term for designating forests and other natural areas which enjoy judicial and constitutional protection under the legal systems of many countries. The term forest reserve may also be used in some contexts in this study area. A reserve forest is covered an area in 215.29 Km^2.

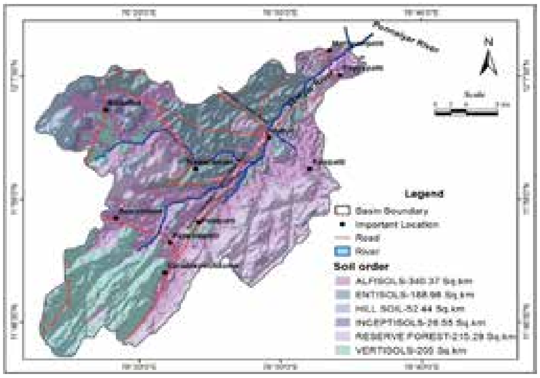

Figure 6: Soil Map of the study area

Lithology

Geologically, the area has been divided into granite ,granitoid gnesis ,pink migmatite, purple conglomerate ,sandstone, shales with limestone, syenite and the presence of water in fracture , so it is given higher preference in determining the groundwater prospect.

GROUNDWATER PROSPECT ZONES

Groundwater prospect zones (Fig.8) were delineated through the integration of the reclassified raster map layers of geomorphology, slope, drainage density, and lithology and soil using the weighted overlay analysis by ArcGIS. The various categories of groundwater prospects distributed in the study area are presented in Table 1. In the study area most of area fall by Good (42%) to very good (0.33).

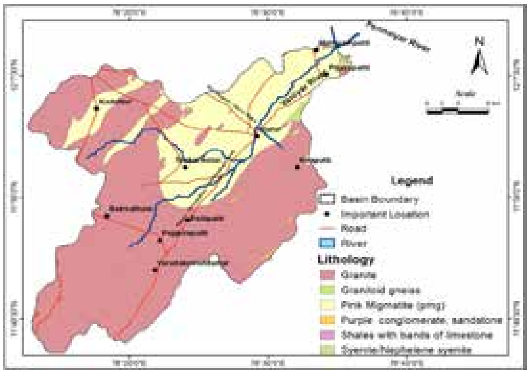

Figure 7: Lithology Map of the study area

Volume : 6 | Issue : 2 | FEBRUARY 2016 | ISSN - 2249-555X

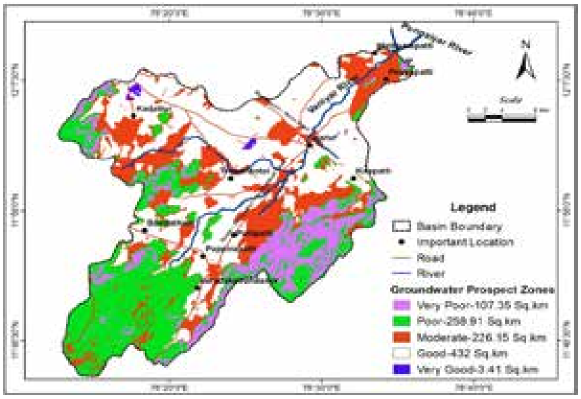

Figure 8: Groundwater Prospect Zones of the study area

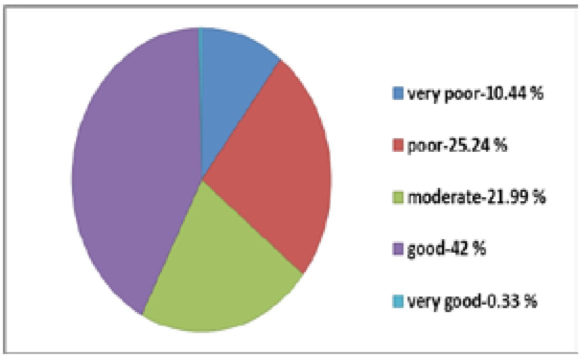

Figure 9: Graphical representation of groundwater prospect zones in the sub basin

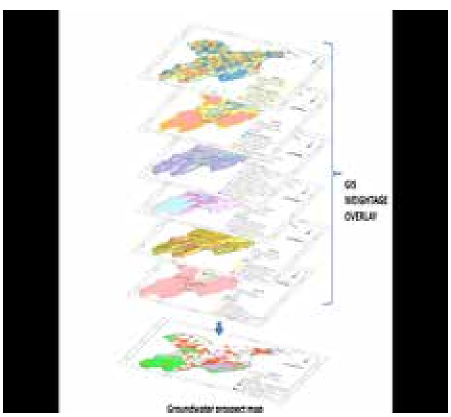

Figure 10: Spatial integration and demarcate groundwater recharge prospects zone

CONCLUSIONS

The groundwater prospect zone indicate that the most effective groundwater recharge prospect zone is located downstream of east west direction. The groundwater in an area is mostly controlled by geomorphology and the features of the terrain like landforms, lithology, soil, drainage, lineament, etc. The study demonstrated the utility of GIS technique in delineating groundwater prospect zones for further exploration and management of groundwater to human consumption and agriculture purpose. The result shows that the distribution of groundwater prospect 'very good and good' is confined to only 42.33 % of the study area, falls in valleys close to the higher order streams. Major portion of the study area falls in moderate (21.99%) class followed by good (42%). the effective in identifying groundwater potential zones which can extensively reduce the cost of well drilling by minimizing the failure of obtaining suitable well sites. Above, the information has provided for groundwater prospect zones helps in identifying for areas suitable around artificial recharge to ensure sustainable groundwater draft.

Acknowledgement

The authors wish to thanks Department of Science and Technology (DST) - Natural Resources Data Management System(NRDMS), New Delhi, India for providing financial support to this research in Department of Geology,Periyar university,salem-11,Tamil Nadu.

REFERENCE

[1] [1]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. [2] [2] Jasrotia, A. S., Majhi A, Singh Sunil (2009). Water balance approach for rainwater harvesting using remote sensing and GIS techniques, Jammu Himalaya, India. International Journal of Water Resources Management, 23:pp. 3035-3055. [3] [3]Krishnamurthy, J., Kumar, N.V., Jayraman, V. and Manivel, M., "An Approach to Demarcate Groundwater Potential Zones through Remote Sensing and GIS," International Journal of Remote Sensing, vol. 17, no. 10, pp. 1867–1884, 1996. [4] [4] Mondal, Md. Surabuddin, Pandey, A. C., Garg, R. D (2009). Groundwater prospects evaluation based on hydrogeomorphological mapping using high resolution satellite images: A case study in Uttarakhand, Journal of Indian Society of Remote Sensing, 36, pp. 69-76. [5] [5]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. [6] [6]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. [7] [7]Saraf, A.K and Choudhary, P.R. (1998). Integrated remote sensing and GIS for groundwater exploration and identification of artificial recharge sites. International Journal of Remote Sensing, 19(10), pp.1825–1841. [8] [8]Saaty, T.L., (1980): The Analytic Hierarchy Process: Planning, Priority Setting, Resource [9] Allocation (New York: McGraw-Hill). [10] [9]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. [11] [10]Strahler A N (1964). Quantitative Geomorphology of drainage basins and channel networks. Handbook of Applied Hydrology; Edited by V.T Chow (New York; McGraw hill) Section, pp 411. [12] [11]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. [13] [12]Vijay Prabhu. M and Venkateswaran. S (2015) Delineation of Artificial Recharge Zones Using GeospatialTechniques In Sarabanga Sub Basin Cauvery River, Tamil Nadu , Aquatic Procedia 4 (2015) 1265 – 1274