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VALUATION OF GROUNDWATER SUSCEPTIBILITY IN AND AROUND RANIPET AREA USING RADICAL INDEX, VELLORE, TAMILNADU, SOUTH INDIA

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ABSTRACT

In and around Ranipet area was bring out in Vellore district, Tamilnadu to improve a realistic new model RADICAL to classify the susceptibility index due to groundwater pollution with growing industrialization, residential, commercial and cultivated purposes. Using RADICAL model is to evaluate the groundwater susceptibility in ARC GIS has come to be well known for actual source and control of groundwater. RADICAL factors are net recharge, aquifer media, and depth of water, impact of vadose zone, hydraulic conductivity, Soil media and Topography (slope) that control the groundwater contamination. Evaluation of RADICAL index contains that multiplication of rating and weight for each factor and to calculate the summation of total weight. In the study area, index value result shown that the susceptibility division between very low to very high susceptibility. The index map outcomes to give more facts about the control of groundwater and future use.

Keywords: Ranipet, groundwater pollution, GIS, RADICAL index, susceptibility

INTRODUCTION

Groundwater pollution is one of the major problems in and around study area. Lacking of water natural life cannot live. Groundwater is a major source of water supply for domestic, agricultural, recreational, and industrial purposes. The suitability of groundwater sources in quality and quantity is most important for extreme dangers from natural and anthropogenic sources such as great residence progress, unexpected urban growth, dumping of solid waste and discarding the domestic and manufacturing wastewater[1]. In addition, groundwater contamination is an indiscernible and irretrievable process, and unreasonable rates and time supplies may limit efforts to develop the groundwater condition[8]. Hence, controlling or decreasing groundwater contamination is an important role in Groundwater resource management. Assessment of Groundwater pollution damage is very suitable device for groundwater management and monitoring[12]. Groundwater quality is mainly depends upon the physical, chemical, biological and number of individual hydrological parameter[13]. Therefore, the control of groundwater pollution is important for valuable groundwater measurement such that the RADICAL index is cost-effective method and reduce the amount of period to calculate the highly pollution area and unrestrained growth area. Susceptibility maps have become an important tool for groundwater prevention and resource management.

The objective of the study area is to evaluate the groundwater susceptibility of any hydrogeological settings using RADICAL index.

Study area

Vellore district lies between north to east is of the South Indian state, Tamil Nadu having 135 km west and lies in the Eastern Ghats region. It has an area of 6077 km² and major town include Ambur, Arakkonam, Jolarpet, Pallikonda, Gudiyattam, Pernambut, Ranipet, Sholinghur, Tiruppattur and Vaniyambadi. In and around Ranipet area lies between North Latitude N12°52′30'' - 12°57′30'' and East

Longitude E 79°15'00'' - 79°25′00' in Figure - 1. It has an area covers about 154.52 sq.Km. The area included those four taluks such as Ranipet, Melvisharam Arcot and Walajapet.

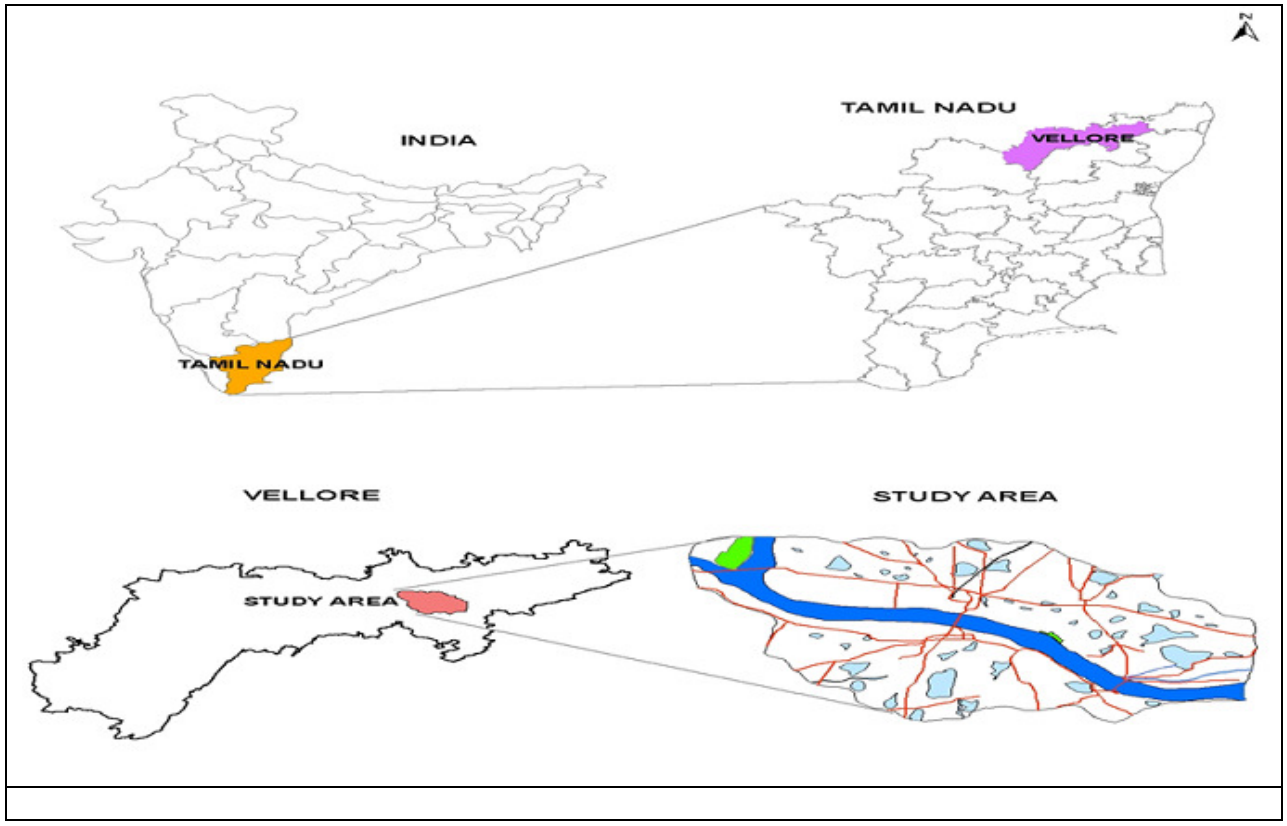

Fig. -1: Location map of in and around Ranipet

The average maximum and minimum temperature qualified are 38.5 degree Celsius and 15.5 degree Celsius. During summer and winter having mean daily temperature are 45.5 degree Celsius and 4.6 degree Celsius. The district region experiences an average annual rainfall of 784 mm, out of which North East Monsoon contributes to 542 mm and the South West Monsoon contributed to 448 mm. The hill station of Yelagiri is presented in the district at Vaniyambadi to Tirupattur road and an altitude of 1,111 metres above Mean Sea Level and spread across 30 Sq.Km. The four areas are located on the banks of Palar River. The topography with slopes is just about plain from west to east and is one of the major sources of groundwater in this area. The moisture ranges from 44%–68% during summer and 68% - 85% during winter. The different varieties of soils such as Black loam, gravel, sand and stone are found in the area. Quaternary deposits are signified by alluvial sand and clays, regulated to the Palar River and its tributaries. Beneath water table settings, groundwater takes place in alluvial deposits as well as in Achaean rocks, granite, gneisses and charnokite. Alluvium and clay found in unconfined to semi - confined conditions down to 50 m bgl. The Palar River is surrounding lakes such as Puliankannu and Karai which is major surface source and are polluted by disposal of various industrial effluents. Many tanneries industries are discharging their effluents into the lakes, rivers, undeveloped land and causing ecological matter and human health hazards. Apart from that land use and land cover is very essential for much development, environmental management purposes and also for groundwater monitoring and modeling. This map is generally developed from native to state to total scales in Figure - 2. Indian Remote Sensing Satellite image have been used for land use and land cover map. The detail of varieties of land use and land cover of the study area in Table - 1.

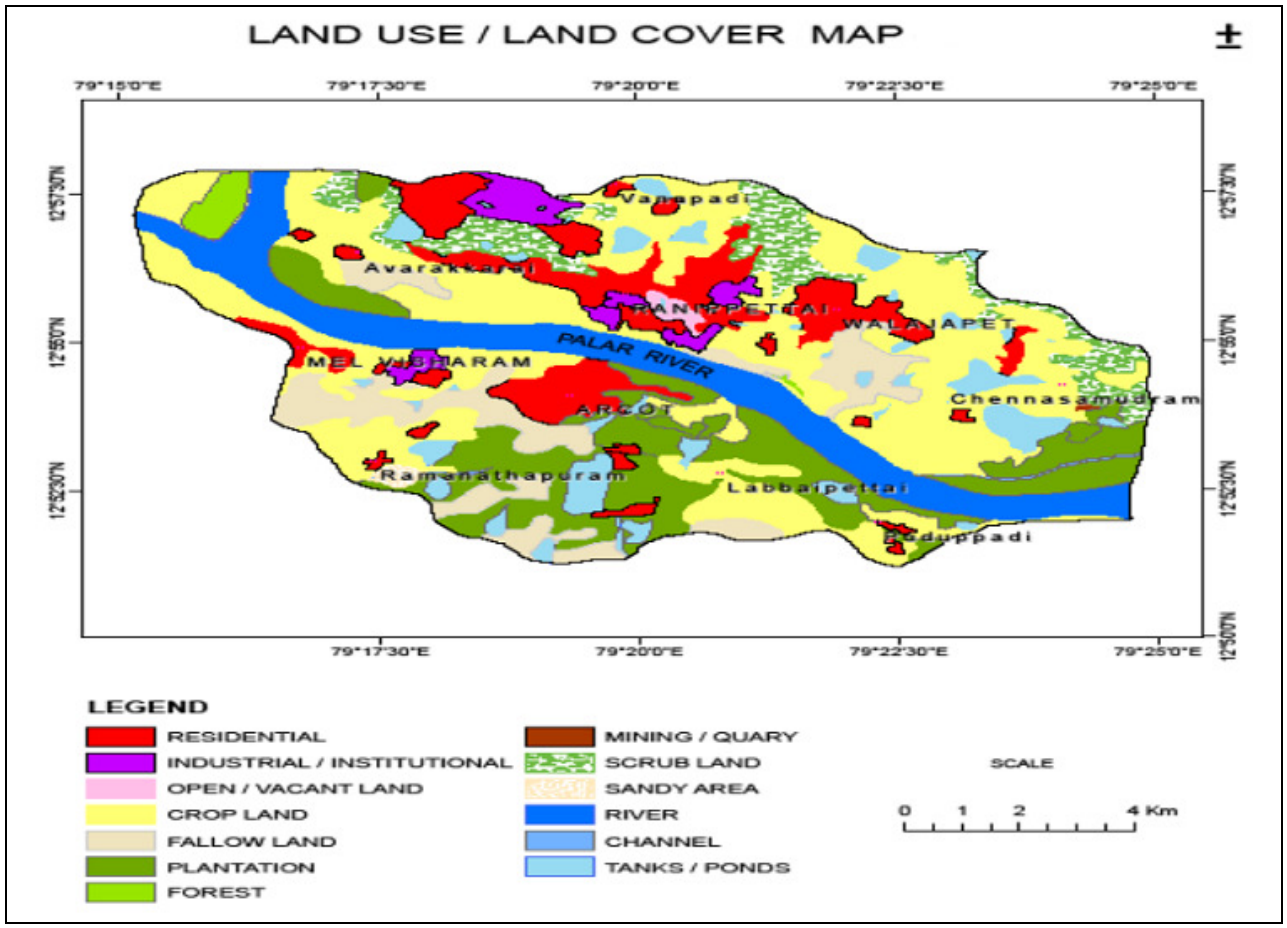

Fig. - 2: Land use /Land cover map of the study area

Table -1: Varieties of land use and land cover with area and percentage

S. No.	Varieties of land use and land cover	Area in sqkm	Percentage of area (%)
1	Residential	19.17	12.40
2	Industrial / Institutional	4.01	2.60
3	Open / vacant land	0.54	0.35
4	Crop land	48.50	31.40
5	Fallow land	14.01	9.06
6	Plantation	24.40	15.80
7	Forest	1.63	1.05
8	Scrub land	11.50	7.44
9	Mining / quary	0.12	0.07
10	Sandy area	0.43	0.28
11	River	19.15	12.40
12	Channel	0.52	0.34
13	Tanks / Ponds	10.54	6.81
	TOTAL	154.52	100.00

EXPERIMENTAL

RADICAL Model

Many models are used to evaluate the groundwater contamination which permits the groundwater contaminants. The study area has been many polluting problems suggest or implement of one new model called **RADICAL**. The physio-chemical characteristics and heavy metal are essential in all hydrogeological settings which have an impact the groundwater pollution potential. Radical factors that control or prevent the groundwater potential are Net **R**echarge, **A**quifer media, **D**epth of water, **I**mpact of vadose zone, hydraulic **C**onductivity, Soil Media is represent as **A** and S**l**ope. **RI** - RADICAL index is an evaluating of each factor has been assigned a weight ranges from 1 to 5, highest and least significant factors having weight of 5 and 1in Table - 2. Each RADICAL range has been assigned a rating which has an impact on pollution potential between 1 and 10 are least and highest pollution potential. The equation of RADICAL index for calculating is Equation - 1.

$$RI = R_R R_W + A_R A_W + D_R DW + I_R I_W + C_R C_W + A_R A_W + L_R L_W \quad (1)$$

Where, R, A, D, I, C, A, L are the factors, Suffix R and W are the rating and weight of each factor for the study area.

Table - 2: RADICAL factors has been assigned weight

Factors /Classes/Features	Assigned Weight
R - Net Recharge	4
A - Aquifer media	3
D - Depth of water	5
I - Impact of vadose zone	5
C - Hydraulic Conductivity	3
A - Soil Media	2
L - Slope	1

RESULTS AND DISCUSSION

Algebraic ranking method is to evaluate groundwater pollution potential in hydrogeological settings has been created or implemented using RADICAL factor. This method consists of three major measures such as weights, ranges and ratings and has been evaluated depends on the rainfall data, pump test data and with different thematic maps such as geology map, land use/land cover map, digital elevation model. RADICAL factor has been discussed below.

Net Recharge (R)

Net recharge called deep drainage or deep percolation that is a hydrologic process where water moves down from surface water to groundwater. Various ranges of recharge values were determined and ratings were assigned in the study area. The recharge values observed in the study area ranges from 1 to 8 in Table - 3. The spatial variation or distribution of net recharge of the study area is in Figure - 3.

Table - 3: Ranges and Ratings equivalent to net recharge of the study area

Range	Rating
Built Up / Mining / Quary	1
Open / vacant land / scrub land	3
Sandy area	5
Crop land / plantation / fallow land / forest	6
Water bodies	8

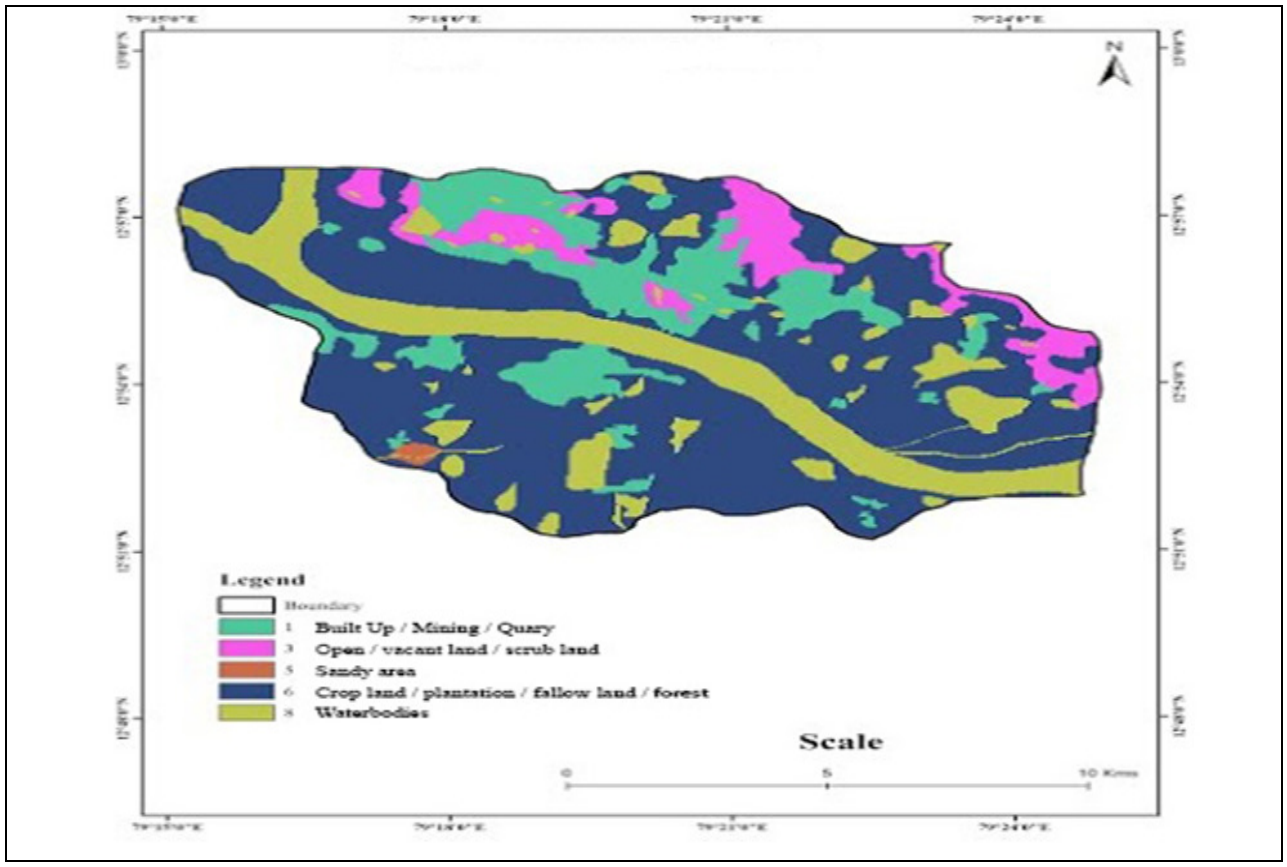

Fig. - 3: Spatial variation of net recharge map

Aquifer Media (A)

Generally an aquifer is a groundwater offering fracture of rocks contains gravel, sand or silt and permeable rock from which groundwater can be dig out using a water well. It depends upon the geological formation of the study area which has different ranges such as charnokite or granite, gneisses and gravel were assigned the rating of 3 to 8 in Table - 4. The spatial distribution of aquifer media of the study area in Figure - 4.

Table - 4: Ranges and Ratings equivalent to aquifer media of the study area

Range	Rating
Charnokite / granite and gneisses complex	3
Granite and gneissic complex / fissile hornblende gneiss	4
Gravel, sand, silt	8

Depth of water (D)

Using the pumping test data was determined the value of depth of water which has ranges varies from 2.9 to 8.4 m below the ground surface of the study area. Based on the RADICAL factor, the rank of the rating assigned between 7 and 9 in Table - 5 and the spatial distribution of depth of water in Figure - 5.

Table - 5: Ranges and Ratings equivalent to depth of water of the study area

Range in meter	Rating
2.9– 4.5	9
4.5 – 8.4	7

Impact of vadose zone (I)

The vadose zone also called the unsaturated *zone* between the land surface and the top of the phreatic *zone*, the position at which the water in the soil's pores is at atmospheric pressure This vadose zone includes that tanks or ponds, clay, channel, sandy clay, sandy clay loam which has assigned the rating value from 1 to 9 in Table - 6. Spatial distribution of impact of vadose zone map of the study in Figure - 6.

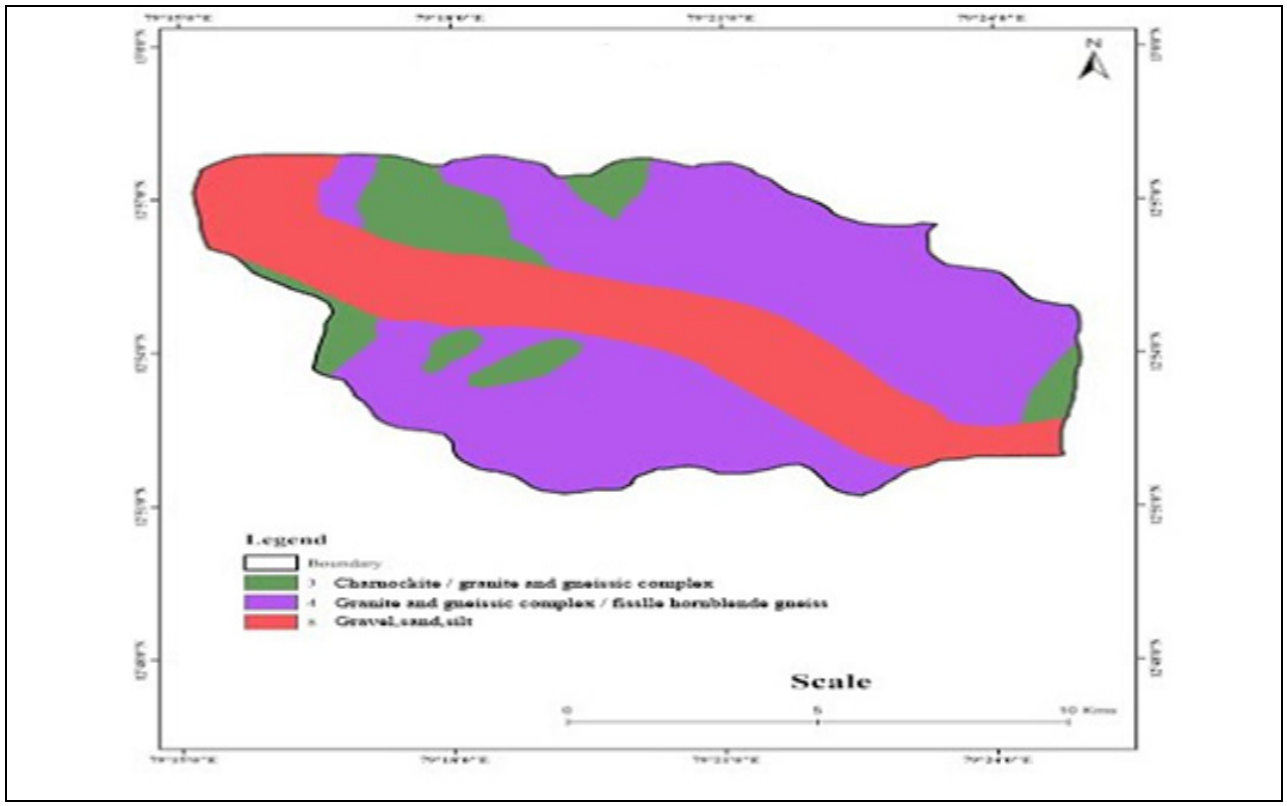

Fig. - 4: Spatial variation of aquifer media map

Table - 6: Ranges and Ratings equivalent to impact of vadose zone of the study area

Range	Rating
Tanks / Ponds	1
Clay	3
Sandy clay/Loamy sand	4
Channel	6
Clay Loam	7
Sandyclayloam	8
Sandy clay	9

Hydraulic Conductivity (C)

Hydraulic conductivity is calculated from pumping test data having a fundamentally properties of vascular plants, soils and rocks, that regularly water can move through pore spaces or fractures or cracks. The range of hydraulic conductivity has been 20m/day to 30 m/day in the study area. Ranges such as river, tanks, ponds, sandy clay loam, clay loam, Sandy clay and clay have ratings are 0 and 1 in Table - 7. Spatial distribution of hydraulic conductivity of the study area in Figure - 7.

Table - 7: Ranges and Ratings equivalent to hydraulic conductivity of the study area

Range	Rating
River/Tanks/Ponds	0
Sandy clay loam/Clay loam/Sandy loam/Clay	1

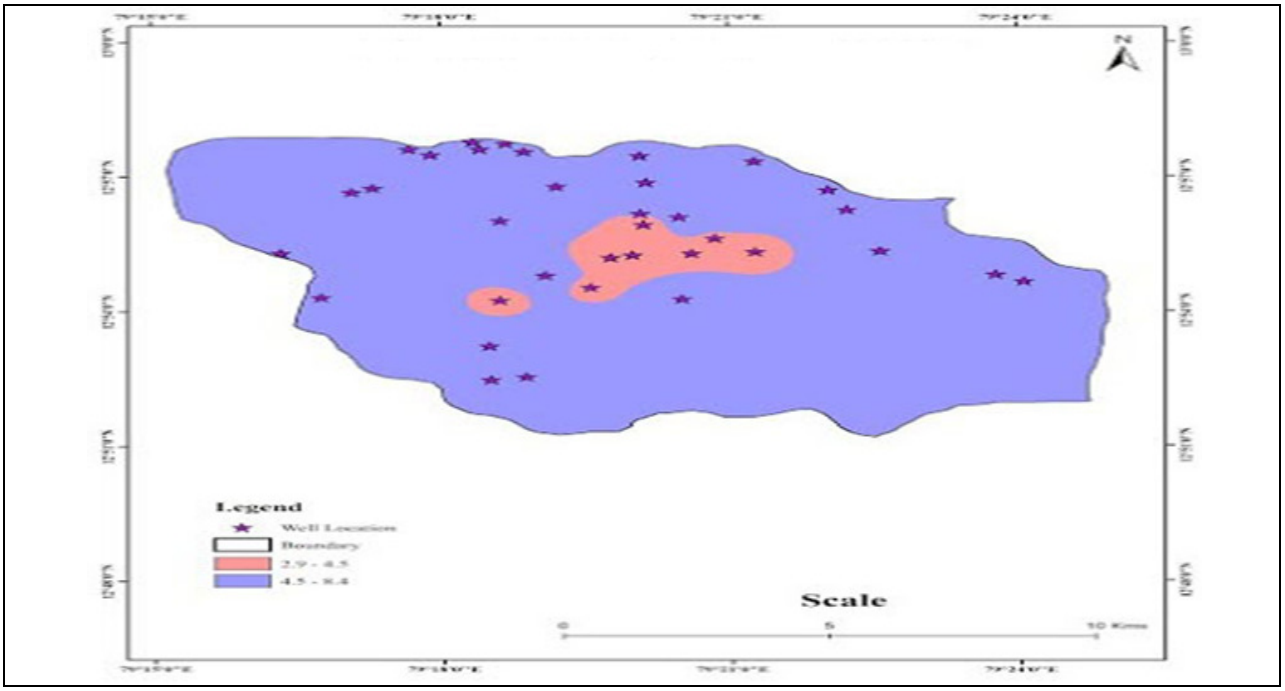

Fig. - 5: Spatial variation of depth of water map

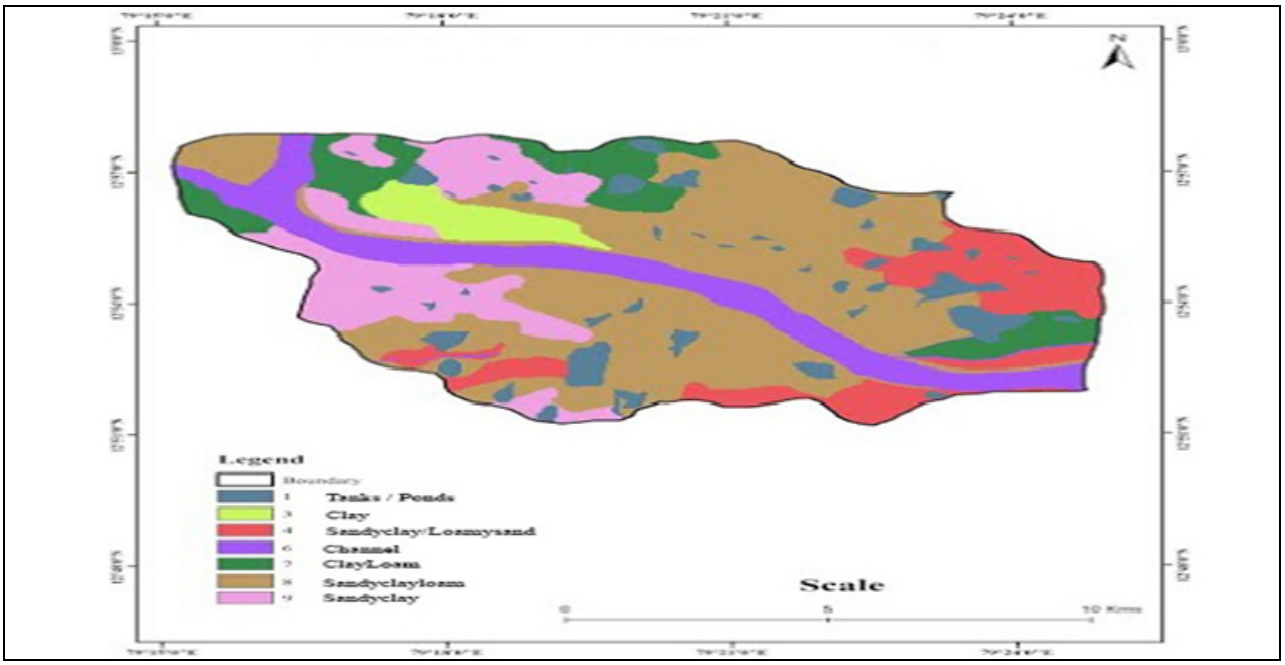

Fig. - 6: Spatial variation of impact of vadose zone

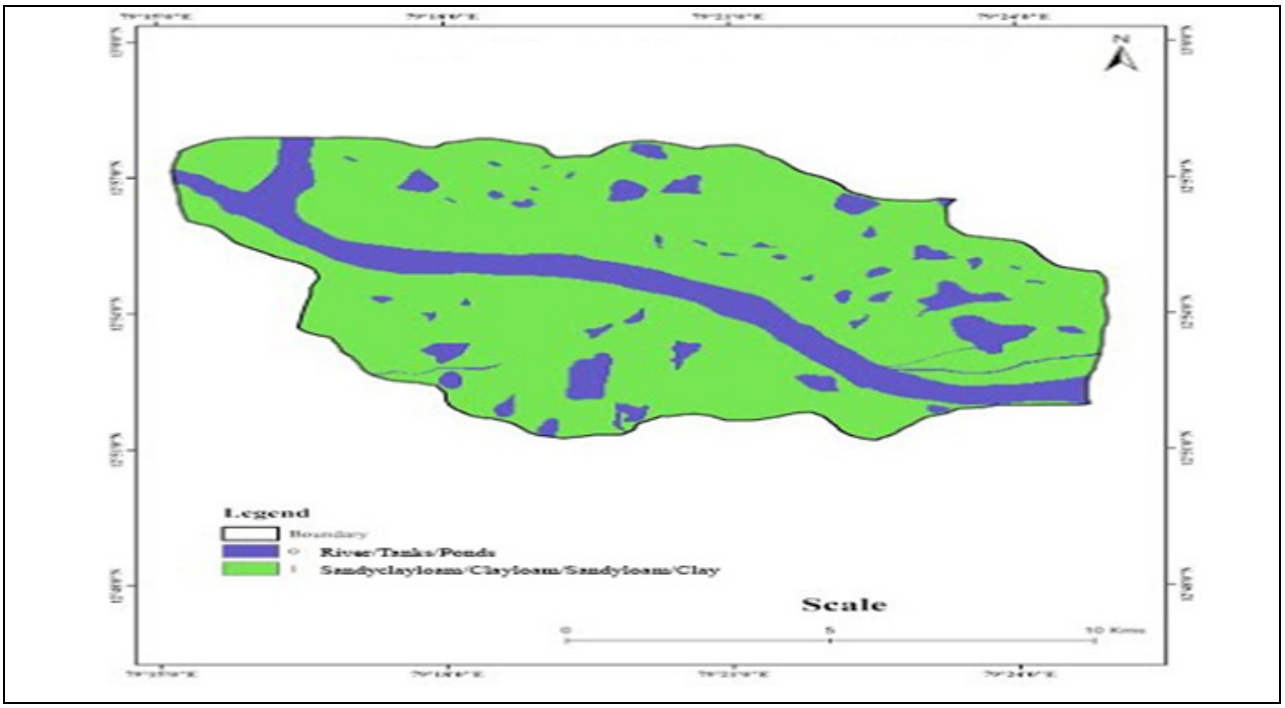

Fig.-7: Spatial variation of hydraulic conductivity

Soil Media (A)

Soil media is represented by letter as 'A' of the study area. The soil media occurs in the groundwater table passes through infiltration. Various ranges such as sandy clay, sandy loam, tanks, clay loam, ponds and channel has been assigned the ratings of 1, 3, 6, 7, 8, 9 and 10 in Table - 8. Spatial distribution of soil media of the study area in Figure - 8.

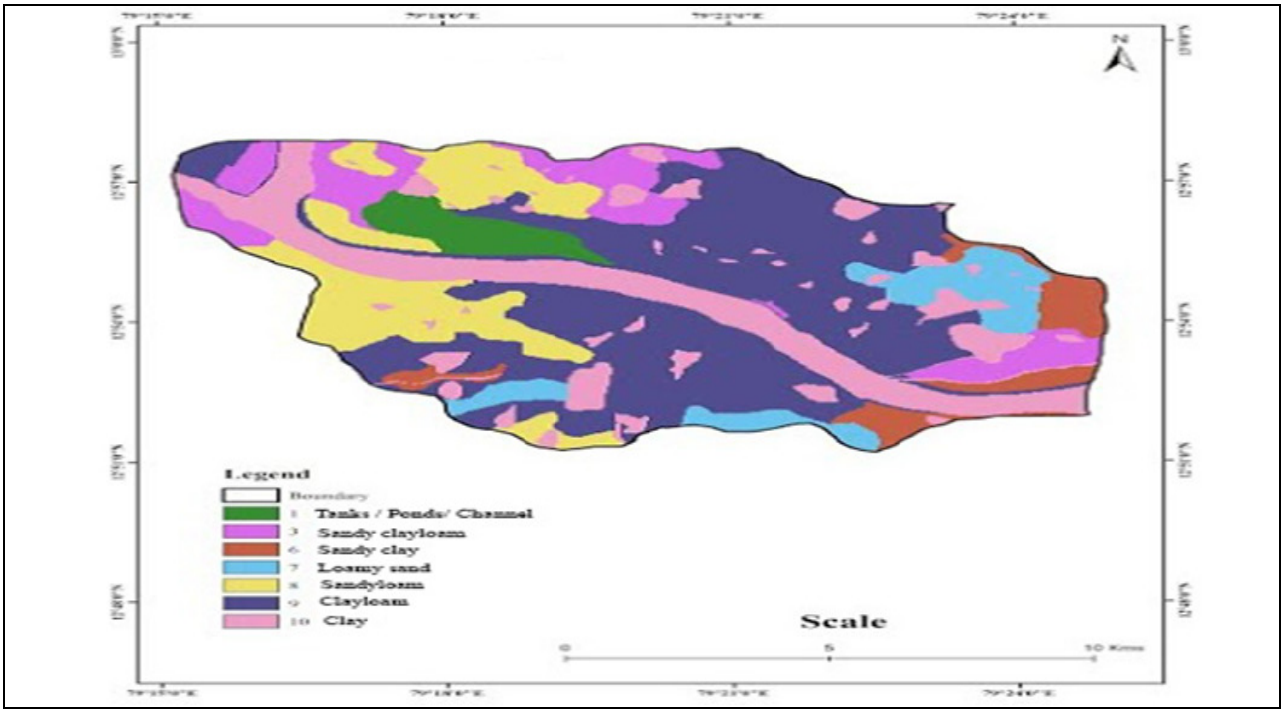

Fig.-8: Spatial variation of soil media

Table - 8: Ranges and Ratings equivalent to soil media of the study area

Range	Rating
Tanks / Ponds/ Channel	10
Sandy clayloam	9
Sandy clay	8
Loamy sand	7
Sandyloam	6
Clayloam	3
Clay	1

Slope (L)

Slope called Topography and it is represented by letter as 'L' of the study area. Slope value was designed from the Digital Elevation Model to calculate the recharge rate has been modified takes place RADICAL division. Slope has to prevent the various pollutants to maintain the surface water. Topography has been arranged for more pollutants to penetrate with the greater groundwater pollution potential. Slope range from 0 to greater than 18 and ratings was assigned 10, 9, 5, 3 and 1 in Table - 9. Spatial distribution of slope map of the study area in Figure - 9.

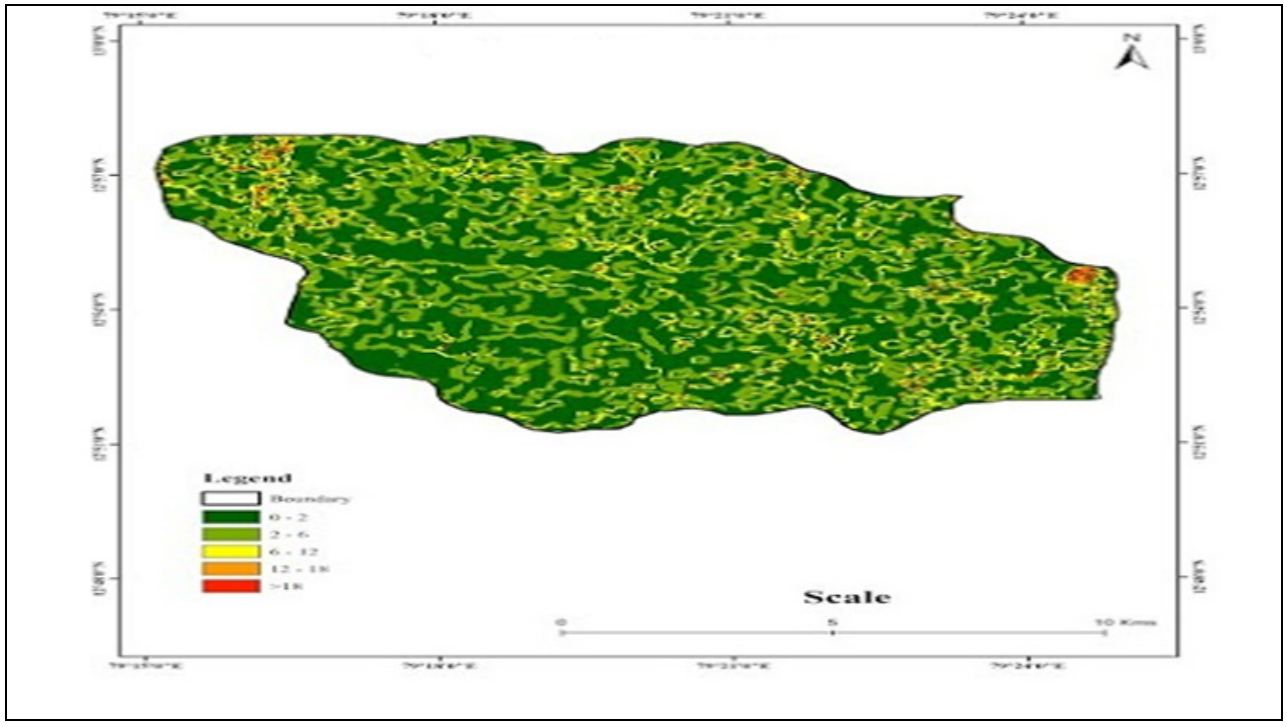

Fig.-9: Spatial variation of slope (Topography)

RADICAL index of the study area

Measurement of pollution problems present in the study area are caluated by RADICAL Index, using the formula of summation of rating and weights of all seven factors. Using the RADICAL index values has been identified area present in the highly pollutants. Susceptibility range varies from 58 to 128. This ranges are classified into three categories that is 58 - 98, 98 - 113 and 113 - 128 resultant to low, moderate and high susceptibility area in Table - 10. These divisions has been prepared a groundwater susceptibility index map in Figure - 10. This map prepared in percentage which indicates that 51.28 % area presence in low susceptibility area, 14.22 % area presence in moderate susceptibility area and 12.45 % area presence in high susceptibility area respectively.

Table - 9: Ranges and Ratings equivalent to slope of the study area

Range	*Rating*
0-2	10
2-6	9
6-12	5
12-18	3
>18	1

Table - 10: RADICAL index values with categories, Ranges and Percentage - study area

S.No	Categories	Range of index value	Percentage of susceptibility area
1	Low	58 – 98	51.28%
2	Moderate	98 – 113	14.22%
3	High	113- 128	12.45%

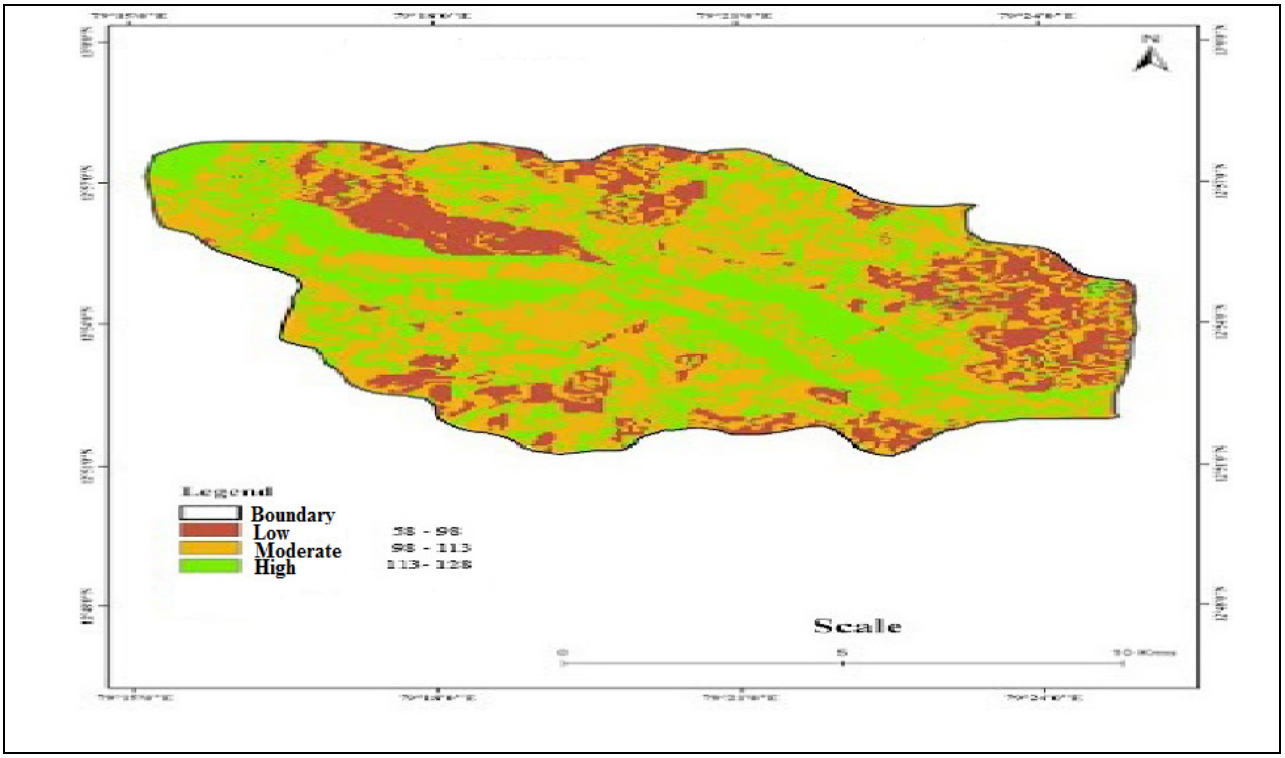

Fig. - 10: RADICAL index value map of the study area

CONCLUSION

This study area is confirm to determine the susceptibility index using the realistic method of RADICAL problem in and around Ranipet. Under the concept of seven RADICAL factors are denoted as hydrogeological settings that is Net Recharge, Aquifer Media, Depth of Water, Impact of vadose are, Hydraulic Conductivity, Soil Media and Slope and Topography. The range of Susceptibility index values from 58 – 128 has been classified as three categories contains 51.28 % area in low susceptibility area, 14.22 % area in moderate susceptibility area and 12.45 % area in high susceptibility area.

The groundwater susceptibility potential map results show that the green color represent as highly polluted in Palar River due to discharging the effluent from many tanneries industries. Orange color represent as

moderately polluted in Ranipet area due to presence of tanneries industries and dumping into solid wastes from residential, industrial and commercial area.

Brown color represent as low polluted in Arcot, Melvisharam and Walajapet due to many open and tube wells present in these villages and agricultural places that affect the groundwater pollution, soil reduction, human health and vegetation. The result of susceptibility map has been created to find out the polluted area were adopted for future use in which further expected to be prone to groundwater pollution.

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