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Mapping Groundwater Potentiality Using Petro Physical propertiesin Osmania University Campus, Hyderabad, Telangana State, India.

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ABSTRACT: *Physical property of a rock is its specific behaviour under the action of some physical field. The study area, Osmania University(OU) Campus is characterized by hard granitic terrain and faces acute water shortage. In an attempt to study the ground water problem in this area, 230 rock samples are collected from 31 locations to study the physical properties viz. density, porosity, permeability, electrical conductivity, magnetic susceptibility. Using the different laboratory methods for each physical property, the results are obtained and compared with the existing literature and it is noticed that the percentage of error is very meagre. Further, to understand the variation of these values in the entire study area, individual property contour maps are prepared by using evaluated physical properties of rocks.Inter relationsbetweenphysical properties of rocks in the OU Campusare studied and variation of physical properties is correlated with the geology of the study area to understand groundwater conditions in the campus area. In addition, four traverses are considered on the same map from west to east and variations of physical properties with respective to geology are explained to understand realisticdistribution of aquifer flow and storage properties. From these studies, it is noticed that availability of groundwater is not uniform and it varies from place to place in the entire study area.*

KEYWORDS: *correlation, groundwater potential zones, hard rock terrain, physical properties, rock samples.*

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I. INTRODUCTION

Water is an essential element in human life. Because of the decreasing surface water bodies, the importance of groundwater exploration is increasing. Groundwater plays an important role in domestic, industrial and irrigation sectors. The study area Osmania university campus is facing the water shortage for hostels, departments, vegetation etc., Our present study deals with studying the petro physical properties of hard granitic rocks, their classification, distribution and hence to explore groundwater potential on the basis of physical properties. Aslight variation in mineralogical composition or variations in rock due to weathering, fractures, there will be subtle difference in value of density, magnetic susceptibility, porosity, permeability and electrical conductivity etc.,these properties are determined in laboratory by using various methods. Interrelations of physical properties of rocks in relation to groundwater resources are studied.

II. GEOLOGY

The study area OU campus, Hyderabad, Telangana is located between 17°23'45"N-17°25'42"N and 78°31'00"E-78°32'26"E over an area of 29 sq.km.. It lies in the toposheet no.56K/11/N-W of Survey of India and was covered by Archean granites, gneisses and intruded by dolerite dykes and several lineaments. The drainage pattern is of mostly dendritic and it is radial at some places. There are two water resources in campus are Mohini cheruvu and Landscape garden tank, the latter was dry because of drought conditions. The average rainfall of the area is 810mm. The groundwater is extracted through bore wells in the campus area. The geology map of the study area is shown in Fig.1.

III. PRESENT STUDY

In order to map the groundwater potentiality of the study area using physical properties, 230 rock samples were collected from 31 locations. At some places depending on the necessity, at least five or more samples were collected.

Of 230 rock samples at least 2 or 3 cores were taken from each sample. Samples which are either too small or too soft were excluded from the investigations. Thus a total 204core samples were investigated for physical properties using laboratory procedures. The locations of the samples collected are indicated in the below Fig.2.

IV. PHYSICAL PROPERTIES:

Physical property is the behaviour of matter under the action of some physical field[1].They depend on the different internal factors such asmineral composition, grain size, porosity and external factors such as pressure, temperature and other external field factor the amount and nature of the fluid contained in a rock is very important in ground water studies[2]. The following are the important physical properties to study groundwater potentiality in the study area.

4.1. Density

Density of rock is the mass,m per unit volume,v of rock.

$$d= m/V$$

In terms of groundwater, the density d is related to the specific gravity G by the relation

$$G = g. d$$

where, g is gravitational acceleration

In the present study, conventional method is employed to study bulk densities of the collected rock samples.

The resulting density values are varying from 2.54 to 2.80 gm/cc.To understand the variation of density values in the entire study area, density contour map is prepared as shown in below Fig.3. It is observed that the variation of d is very intense in northern portion indicating complexity in lithological and morphological conditions in this part, but it is different in south eastern side of the area.

4.2. Porosity:

Porosity is the amount of pore spaces in a rock. It is defined as the ratio of the void space V_{por} inside the rock, to the total (bulk) volume V_{tot} of the rock

$$\Phi = V_{por}/V_{tot}$$

In the present work, porosities are determined by using Saturation method (by using the vacuum pump).

In the study area, porosity values show the variation from 0.10 to 0.34%. To understand the variation of values in the entire study area, porosity contour map is prepared and presented in the below Fig.4.From figure, it is seen that the variation of porosity is intense in the northern portion, but the same is different in the south eastern side of the area.

4.3.Magnetic Susceptibility

Magnetic susceptibility (χ) is a measure of magnetization of a material in applied magnetic field. In the present investigation magnetic susceptibilities of rock samples collected were measured using standard equipment MS2 Magnetic susceptibility meter **(Barington susceptibility meter).** The below Fig.5. shows the variation of magnetic susceptibility in the study area. It is observed that susceptibility values are decreasing from North to South, whereas they are increasing marginally from East to West.

The values of magnetic susceptibility are ranging from $5.1\text{-}781.8*10^{-6}$cgs.The ratio of the highest to the lowest susceptibility is of the order of $153.2*10^{-6}$cgs. The established variation factor for granites in the study area is under ten [3]. Magnetic Susceptibility of pyroxene granites and porphyritic pink granite are around $781.8 *10^{-6}$ and $5.6*10^{-6}$cgs. There is a sufficient magnetic susceptibility contrast, among the granites thus helping us to differentiate the two varieties of granites geophysically.

4.4. Permeability:

The permeability of rock or soil defines its ability to transmit a fluid. An intrinsic permeability, k may be expressed as

$$k=K\, u/\rho\, g$$

Where K is the hydraulic conductivity, u is dynamic viscosity, ρ is fluid density and g is acceleration due to gravity. It is expressed in meters per day (m/day) or feet per day (ft/day).

In our present study, we have related the porosity with permeability by studying the thin section of different rock samples in different areas from which we calculate the shapefactor $f_s = k = a/b/c$

$$k = f_{s*} f_{\alpha *} d^2$$

Where a= highest value of all of grain size (particular area), b= average value of the grain size,c= lowest value of the grain size,f_α = porosity value of the particular rock,d= diameter of the grainsize.

4.4.1. Thin sections:

Thin sections were prepared from a few representative samples of the Osmania University Campus study area like Arts college, R&D Department, Master in Business Management, Yellamma Temple, Tagore Auditorium, University Library, Workshop, Physical Education, Guest House, Centre for Distance Education, Mess and Warden office etc.

The percentage of quartz grains and size of grainswhich are helpful to find the permeability of rock samples are determined with the help of a microscope containing Electro Automatic Point Counter Model an attachment. It is observed that the grain size of quartz mineral in all the rocks varied from 0.3 to 0.8mm. 27 thin sections were studied covering the entire study area and studied their properties related to permeability and some of them are shown below in Figures 6,7,8. The values of permeability are ranging from 1.06 E^{-08} - 9.07$E^{-09}$$(cm)^2$.

Fig.6. shows the thin section near Godavari Hostel Porosity is less i.e. 0.11% and the permeability is also low i.e. $5.21*10^{-9}(cm)^2$.

Fig.7. Shows the thin section near Microbiology dept. Porosity is high i.e.0.33% and permeability is also high i.e. $1.67*10^{-8}$ (cm) $^{2.}$

Fig.8. shows the thin section near Institute of Public Enterprise Porosity is low i.e. 0.12% and the permeability is also low i.e.$5.08*10^{-9}(cm)^2$.

By substituting the respective values in the equation, $k = f_{s*}\ f_{\alpha\ *}\ d^2$ we get the permeability of the rock samples.From Fig.9. the value of the permeability is more in the South compared to North, whereas permeability is more in the East compared to West.These variations in permeability lead to understanding the differences in lithology like occurrence of pink or grey granites are weathered or fresh granites and also the varying intensity of fracturing and fissuring of granites which show direct bearing on the occurrence, movement and yield of groundwater in the study area.

4.5. Electrical Resistivity

Resistivity ρ, is defined as the resistance offered by a unit cube of the material to directcurrent flowing through it in a direction perpendicular to two of its opposite faces and it is expressed in ohm-metres.$\rho = AV/LI$

Reciprocal of resistivity called the conductivity (σ) expressed in mhos per meter is the quantity used to characterize the flow of current in geological formations.

$\sigma = 1/\rho$

Resistivity measurements were performed on cylindrical samples of approximately 2.5*2.5 cm. Two circular copper electrodes having the same diameter as the sample was used in the tests. To ensure better contact between the electrode and samples, a pad of filter paper soaked in the brine solution or normal water was placed between the cored sample and the copper electrode[4].Using the Resistivity formula $\rho = AV/LI$, the resistivity of rock samples in study area was measured and by using the reciprocal ofρ obtained electrical conductivities of rock samples are ranging from 0 - $38.84*10^{-6}$ mho/m, contour map is prepared and shown in below Fig.9. The value of electrical conductivity is more in the South than North whereas electrical conductivity is more in the East compared to West.

V. INTER RELATION AMONG DIFFERENT PHYSICAL PROPERTIES OF ROCKS IN THE OSMANIA UNIVERSITY CAMPUS

When determining the properties of rocks generally, we consider all the variety of the factors that influence these properties. However, certain general regularity of these variations of one property with change of another can be traced on a graph. The graph itself can be treated statistically. For this purpose Legendre's principle [5] is used, according to which the best approximation to the relationship sought is given by least square approach, in which the sum of the squares of the deviations is minimum. As a result, a correlation can be obtained.

Relations between various physical properties of rocks are determined as shown below:

5.1. Relation between the density and porosity of rocks in the study area is shown in Fig.10.

The straight line was statistically fitted and equation of straight line was determined to be

Equation of straight line was determined to be $d = 0.044*\Phi + 2.613$

SD = 0.05

Mean density =2.613 gm/cc

5.2.Relation between porosity and permeability of rocks in the study area is shown in Fig.11.

From fig., $k = 1.27*\Phi + 0.055$

SD = 0.27

Mean permeability= $0.29*10^{-8}(cm)^2$.

5.3. Relation between electrical resistivity and porosity in the study area is shown in Fig.12.

From figure,

$\rho = -70.90*\Phi + 53.30$

SD = 24.94

Mean resistivity =39.84 ohm m.

5.4. Relation between electrical resistivity and grain size in the study area is shown in Fig.13.
$\rho = 83.74*G+33.17$
SD = 78.61
Mean resistivity= 85.51 ohm m.
5.5. Relation between porosity and grain size in the study area is shown in Fig.14.
From figure, $\Phi = 0.086*G+0.1515$
SD =0.064
Mean Porosity=0.2045%.

VI. PROFILES

To understand the role of physical properties for groundwater prospecting in the study area is interpreted considering the four profiles of different lengths on the geology map of study area from west to east and marked them as L_1N, L_2N, L_3N, L_4N as shown in the below Fig.15.
(a)L_1N - Profile line passes through lineaments/concealed dykes touching the patches of pink/grey granites of northern side of the area.
(b)L_2N – Profile line passes through more lineaments/concealed and exposed dykes touching the important patches of pink/grey granites of central portion of the study area.
(c) L_3N-Profile line passes through lineaments/ exposed dolerite dyke touching the patches of pink/grey granites of central portion of the study area.
(d)L_4N- Profile line passes through lineaments and touching the patches of pink and grey granites of eastern side of the area.
Further, to understand the importance of physical properties, their variation along the each line L_1N, L_2N, L_3N, L_4N is derived using the Geosoftsoftware. The variation of physical properties is correlated with the geology of the area and explained in terms of availability groundwater in the following. Generally, groundwater occurring zones are identified on the basis of physical properties as follows
1) Low density, 2) Low permeability, 3) High porosity, 4) Low Magnetic Susceptibility, 5) High Electrical Conductivity
(a) From the Fig. 16. profileL_1N sudden change in conductivity at 10 mho/m (i.e. from high to low), porosity at 0.6%(i.e. high to low), permeability at $2*10^{-8}$(cm) ^{2}(i.e. from low to high), density at 2.7gm/cc (i.e. from low to high) and magnetic susceptibility at 0.00045cgs (i.e from low to high) that is all the variations are observed at fidicilous 10 i.e. nearly 1000m.Thus, groundwater zone is observed.
(b) From the Fig.17. profileL_2N sudden change in conductivity at 15 mho/m (i.e.from high to low) and porosity at 0.16%(i.e. high to low) and permeability at $1.2*10^{-8}$(cm^2)(i.e. from low to high) and density at 2.60 gm/cc (i.e. from low to high) and magnetic susceptibility at 0.00030 cgs (i.e from low to high) that is all the variations are observed at fidicilous 15 i.e. nearly 1500m. Thus, groundwater zone is observed. Already the groundwater occurrences with high yield bore wells are working in this area (i.e. around V.C junction).
(c) From the Fig.18.profileL_3N sudden change in conductivity at 12 mho/m (i.e. from high to low) and porosity at 0.16%(i.e. high to low) and permeability at $1.6*10^{-8}(cm)^2$(i.e. from low to high) and density at 2.64 gm/cc (i.e. from low to high) and magnetic susceptibility at 0.00020 cgs (i.e. from low to high) that is all the variations are observed at fidicilous 20 i.e. nearly 2000m. Thus, groundwater zone is observed.
(d) From the Fig.19. profile L_4N, sudden change in conductivity at 10 mho/m (i.e. from high to low) ,porosity at 0.12% (i.e.high to low) ,permeability at $1.0*10^{-8}(cm)^2$(i.e. from low to high) and density at 2.65 gm/cc (i.e. from low to high) and magnetic susceptibility at 0.00050 cgs (i.e. from low to high) that is all the variations are observed at fidicilous 15 i.e. nearly 1500m.Thus, groundwater zone is observed.

VII. RESULTS AND DISCUSSION

The values ofdensity to be varying from 2.54 gm/cc to 2.80 gm/cc. For Pink granites densities are varying from 2.54-2.62 gm/cc and grey granites it is varying from 2.57-2.80 gm/cc.

- The porosities of the pink and grey granites are 0.10 % and 0.34 % respectively.For pink granites the porosities are varying from 0.14-0.32 % and grey granites are varying from 0.13-0.24 %.
- The magnetic susceptibility values of pink and grey granites were ranging from 5.1 to $781.8*10^{-6}$cgs. For pink granites, it is varying from 5.1- $679*10^{-6}$ cgs and for grey granites, it is varying from 63.1- $781.8*10^{-6}$cgs.

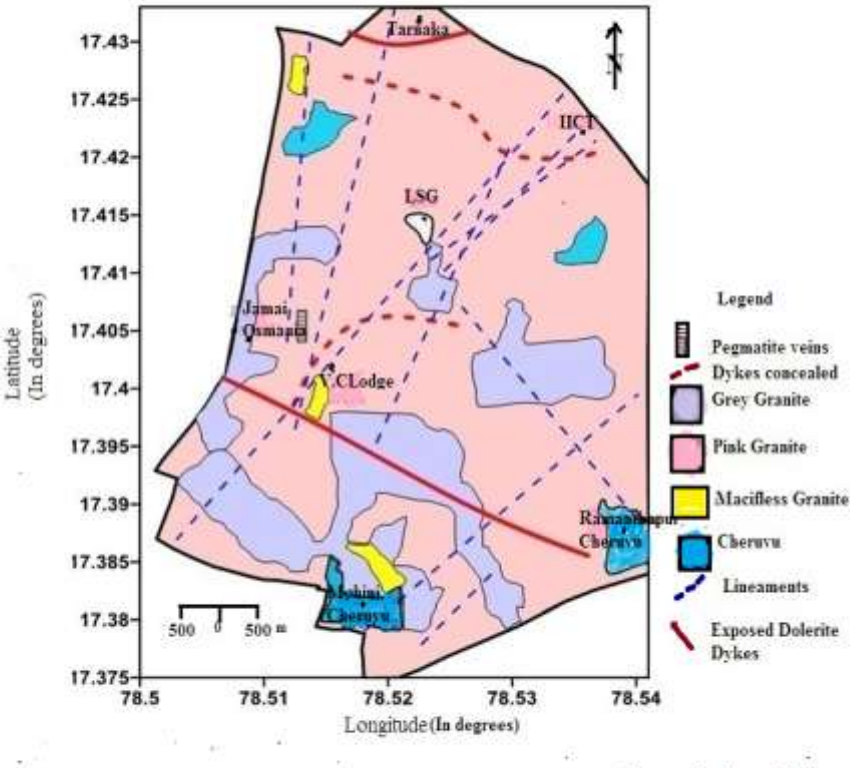
- Electrical Conductivity values of pink and grey granites were ranging from0 to $38.84*10^{-6}$ mho/m.
- Sizes in quartz grains vary from very fine to medium and in a few cases it is coarse. The mean size of the quartz grain in pink and grey granites together was found to between 0.3 mm to 0.8mm.

- Permeability of granites is measured by using intrinsic permeability i.e. grain size, porosity and shape factor relation and the values of pink and grey granites were ranging from $1.06E\text{-}^{08}$ to $9.07E^{-09}(cm)^2$.

Relation between various physical properties are given by,

1. Density decreases with the increase in porosity of the rocks. The relation is
$d = 0.044*\Phi+2.63$
2. Porosity generally increases with size of grain increasing. The relation is given by
$\Phi = 0.086*G +0.1515$
3. Electrical Resistivity of saturated samples increases with increase in grainsize of rocks. The relation is given by
$\rho =83.74* Gr+33.17$
4. Porosity increases with increase permeability of rocks. The relation is
$k = 1.27*\Phi+0.055$
5. Electrical Resistivity of saturated samples decreases with increase in porosity of rocks. The relation is $\rho = -70.90*\Phi+53.30$

VIII. FIGURES



(Source : Raghavan 1999)

Fig.1. Geology map of the study area

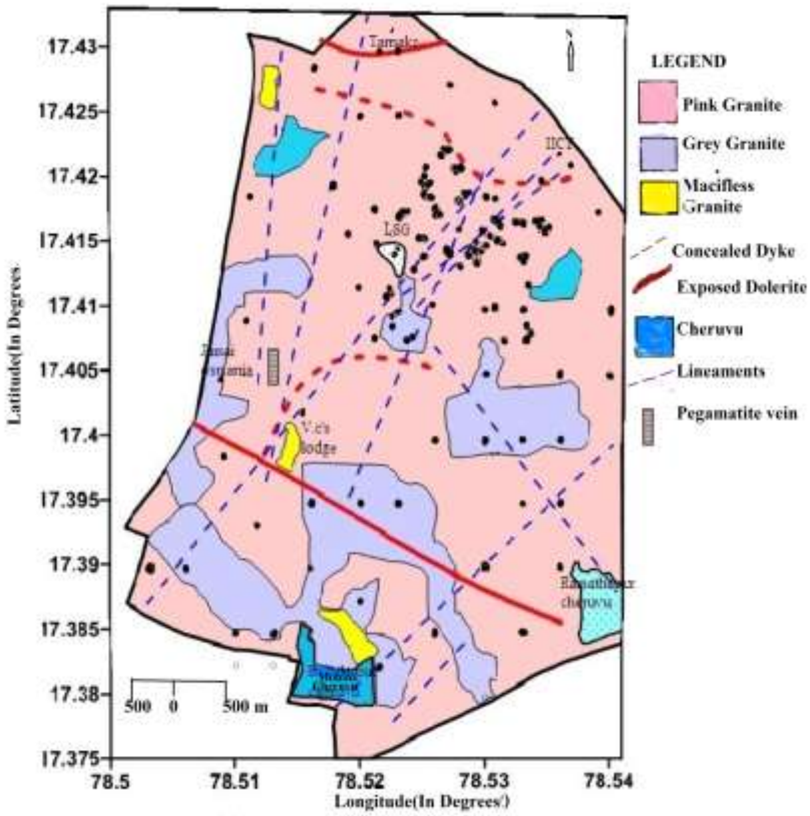


Fig.2. Location of the rock samples in the study area

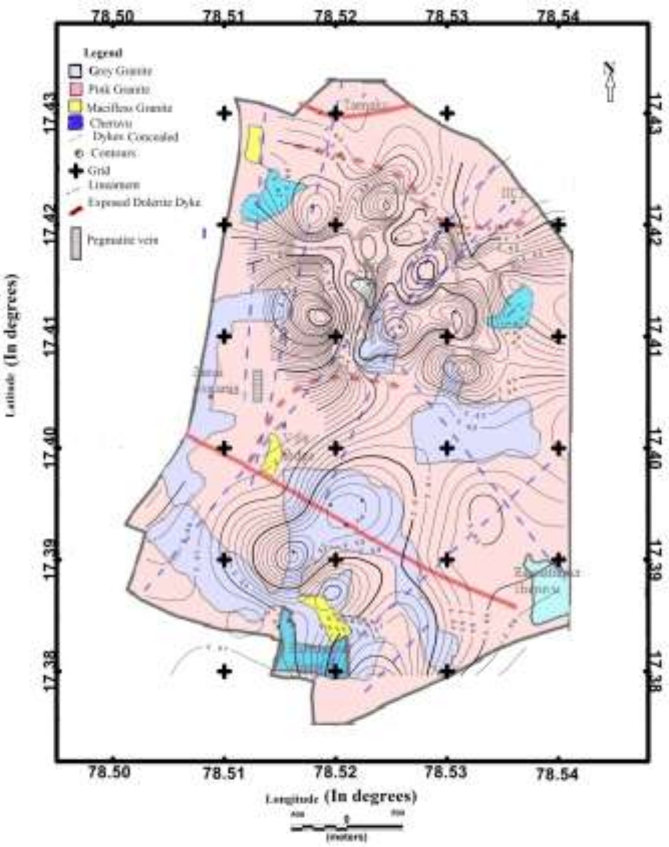


Fig.3.Density contour map of the study area

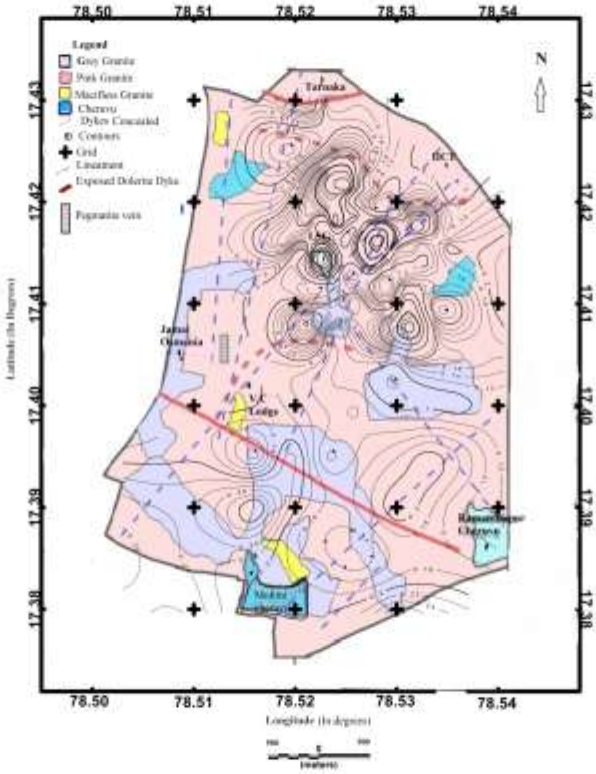


Fig.4. Porosity contour map of the study area

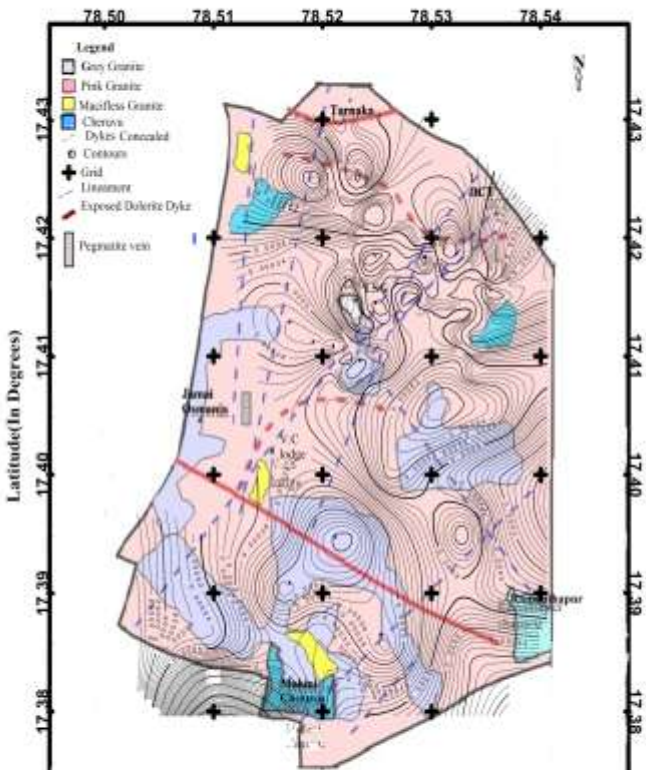
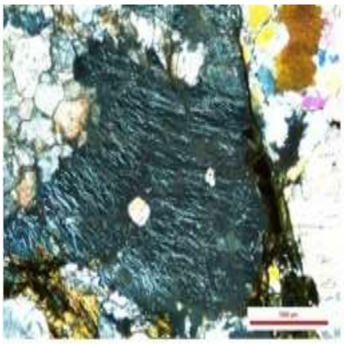


Fig.5. Magnetic Susceptibility contour map of the study area



(a) 1AGD (Godavari hostel)

Fig.6. Thin section near Godavari hostel

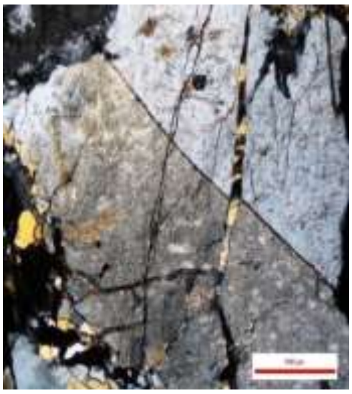


Fig.7. Thin section near Microbiology Department

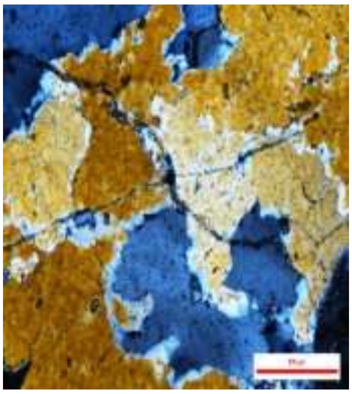


Fig.8. Thin section near Institute of Public Enterprise

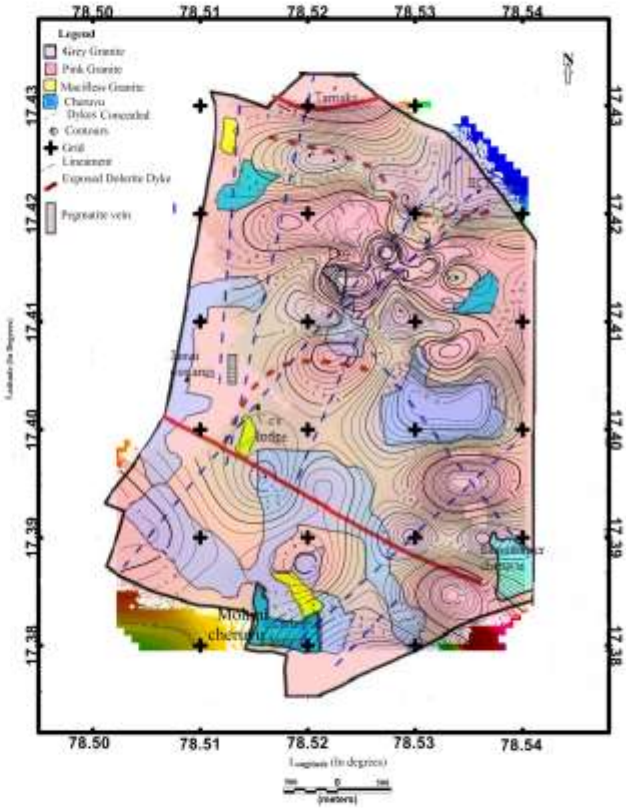


Fig.9. Permeability contour map of the study area

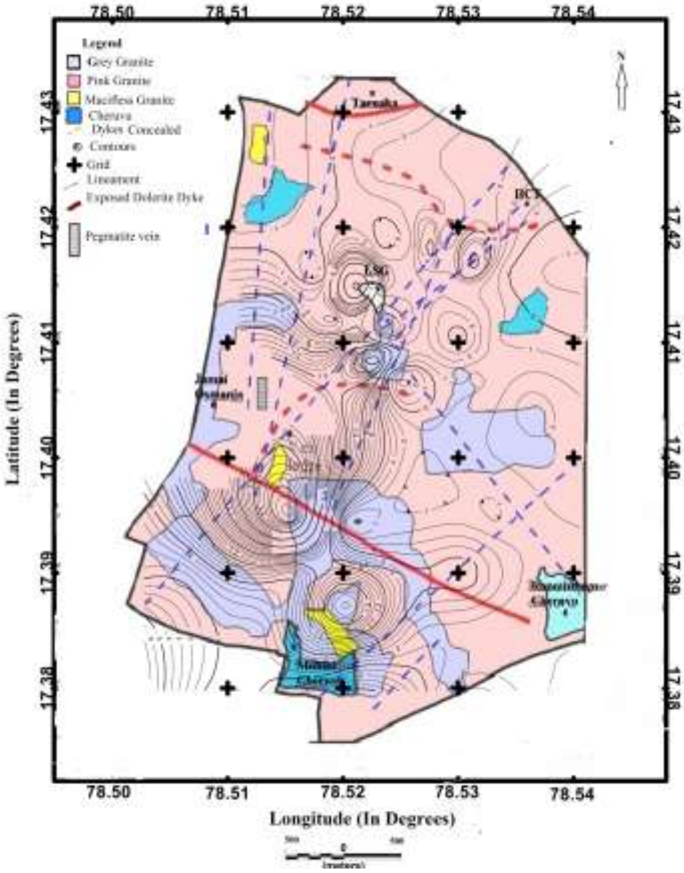


Fig.10. Electrical resistivity contour map of the study area

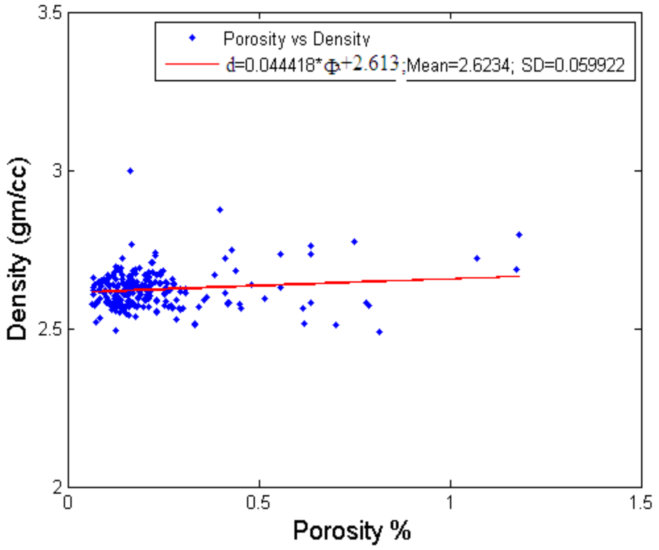


Fig.10. Relation between density and porosity

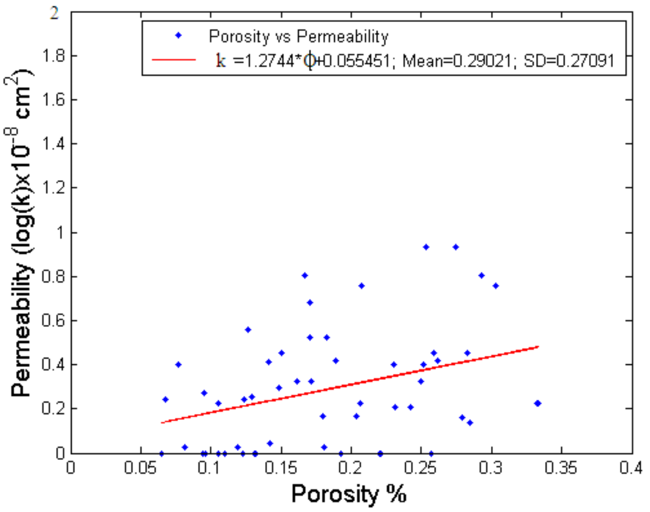


Fig.11. Relation between porosity and permeability

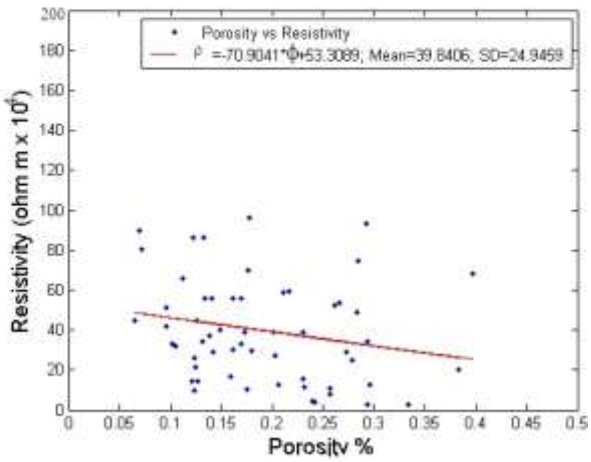


Fig.12. Relation between porosity and resistivity

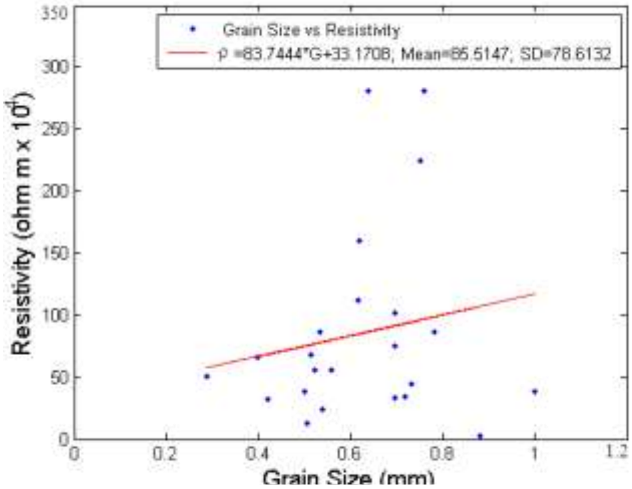


Fig.13. Relation between grain size and resistivity

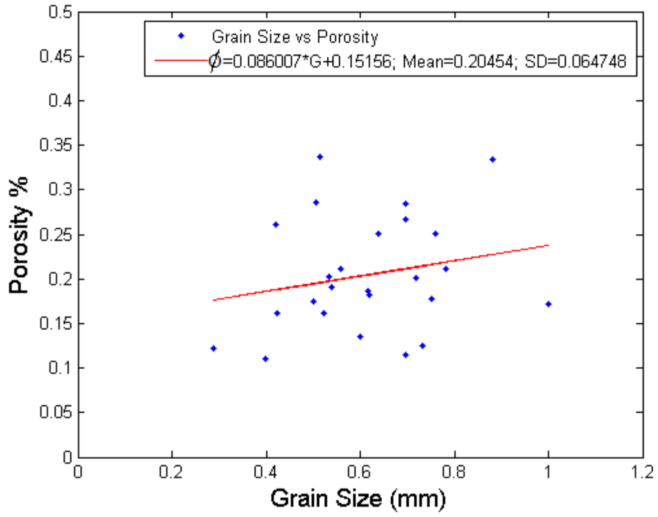


Fig.14. Relation between grain size and porosity

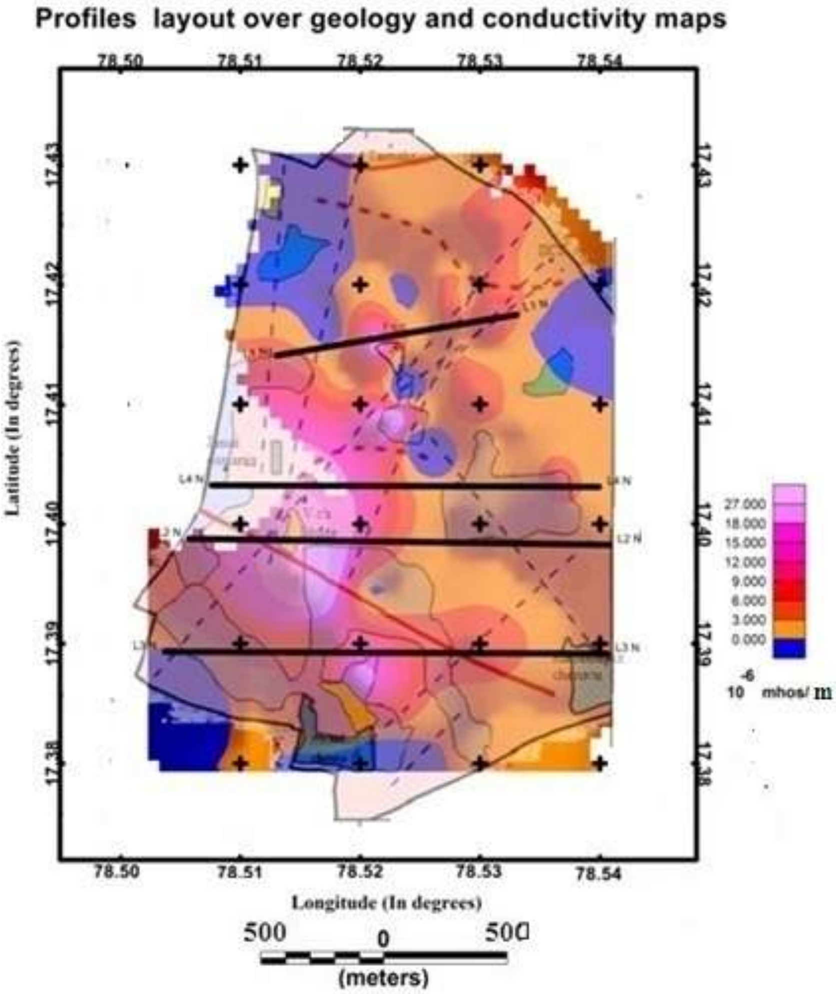


Fig.15. Profiles lay out on conductivity map

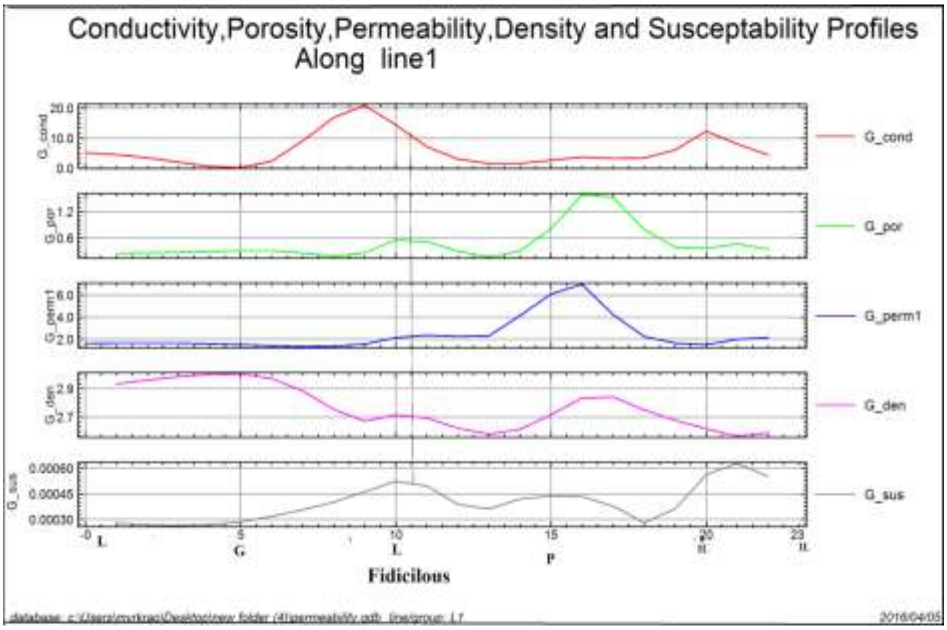


Fig.16. Profile L_1N

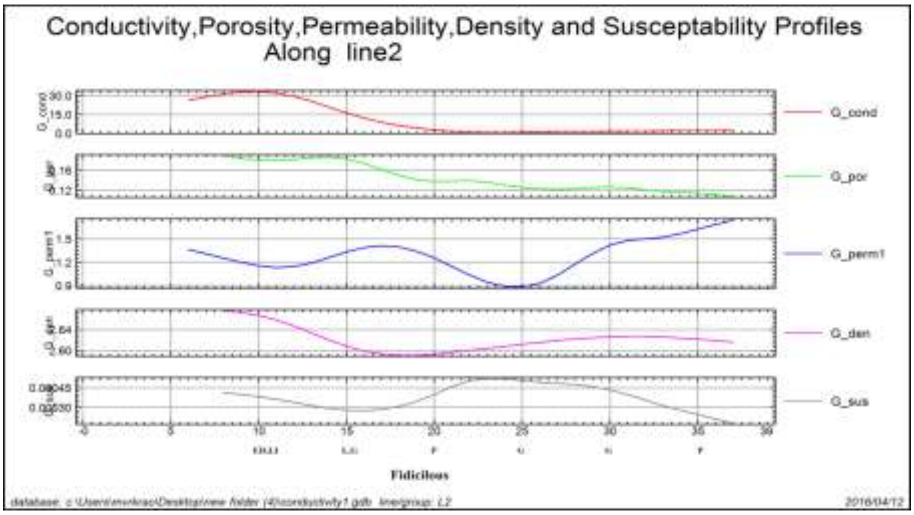


Fig.17. Profile L_2N

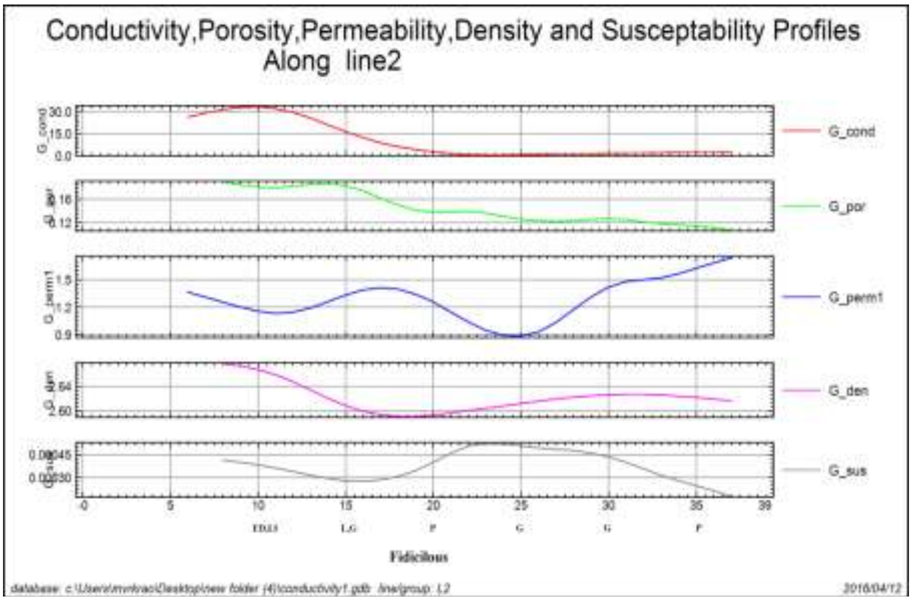


Fig.18. Profile L_3N

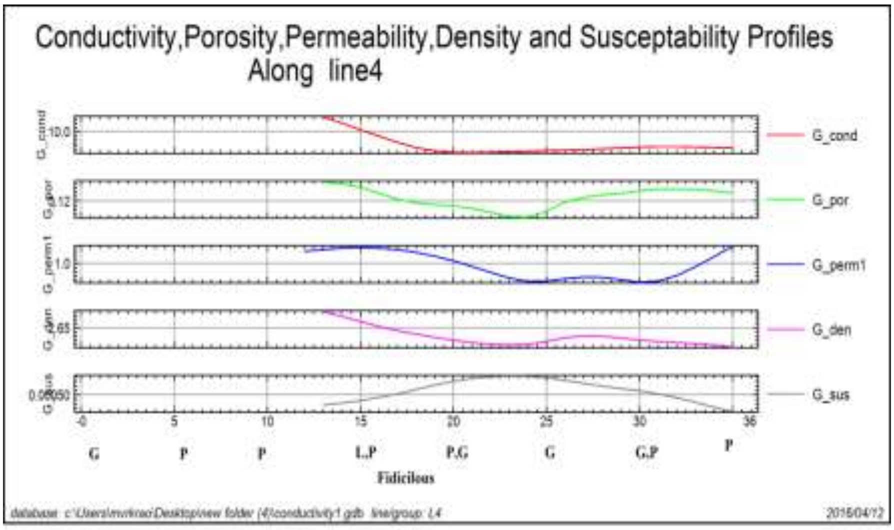


Fig.19. Profile L_4N

IX. CONCLUSIONS

It can be concluded that the physical properties concept together geology and hydro geologically promising zones map are indicative of groundwater potential zones which can be used appropriately by the user. The significance of Physical properties and their interrelations for groundwater availability is discussed in the present study. From these studies, it is noticed that availability of groundwater is not uniform and it varies from place to place in the entire study area. Variation is studied with their interrelations in addition to considering four traverses across the map and correlating with the geology of the study area with a view to understand groundwater conditions in the O.U. Campus area.

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