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Influence of vegetation cover on short distance variations of soil resistivity: An experiment on greyscale (digital) imaging and indexing

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ABSTRACT
This paper attempts to assess the influence of vegetation cover upon physical character of soil within short distance. For that purpose a very small slope of 6m was selected which is covered by various types of natural vegetations like *Cynodon dactylon, Lantana camara, Calamus tennis, and Acacia Arabia and Dracaena spicata*. Soil resistivity metre was used for measuring the electrical conductivity of soil in this area. In the field 4 pin method was used and resistivity character of soil was calculated by $\rho=2\pi aR$. A greyscale index of the soil resistivity was prepared within black to white range. Micrographic study of the soil particles were also done to understand the physical characters of the collected soil samples collected from survey points. Through the study it has been observed that though the area is very small, change of slope angle influenced upon the pattern and distribution of vegetation cover. This study also opens the fact that even within a small area though the general compositions of the soil are similar, resistivity character is influenced by the variation of vegetation cover.

INTRODUCTION

Environmental functions on soil are important parameters to measure its quality (Doran & Parkin, 1994). Among the environmental components vegetation play very important role in physio-chemical and bio-chemical functions in the soil. Vegetation cover also play very important role in geophysical characters like increasing the resistivity of soil (Bernstone et al., 1997). Many works have been done on electric/electromagnetic conductivity of various soils by Palacky (1987); Dahlin (1993); Alfano (1993); Dahlin (1996); Christensen & Sorensen (1996), Dahlin & Loke (1997); Yoshida, Tanaka & Hozumi (1997) to assess the geophysical quality of soils in large areas. Very recent geophysical studies by Gorge, Akpabio & Evans (2008) and Akpan, George & George (2009) focused on the soil loss or changing soil character. From the previous works, one thing is very clear that most of the scientific works on soil concentrated on wide area, though it is well accepted that environmental components have influence even within the smallest scale units (Dey et al., 2008a). It is a fact that small area variations of soil characters are not discussed in most of the scientific literature and only used as passing references. In the present study electrical conductivity of sandy soil has been tested to assess the influence of vegetation cover on variation of resistivity character of soil within a meter scale. A small slope (6m) of Tripura University campus was selected for the purpose (Fig.1). This is a slope of dissected highland which is composed of immature sandy soils (Dey et al., 2008b) and covered by dense to medium dense small natural vegetations (shrubs to grasses). The main objective of this study is to asses the influence of vegetation cover on soil character within meter scale and to prepare a systematic digital index of slope soil resistivity within greyscale or radiometric resolution.

METHODOLOGY

Data generation:

McNeill (1980) described the physical factors for changing the electric conductivity in soil and rock. Since this work concentrates on the small area impact of vegetation cover and variations of physical character of soil, electrical conductivity of sandy soil within 6 m area was recorded during the dry season. Soil resistivity meter (SRM) was used for measuring the electrical conductivity. In that survey 4 Pin method

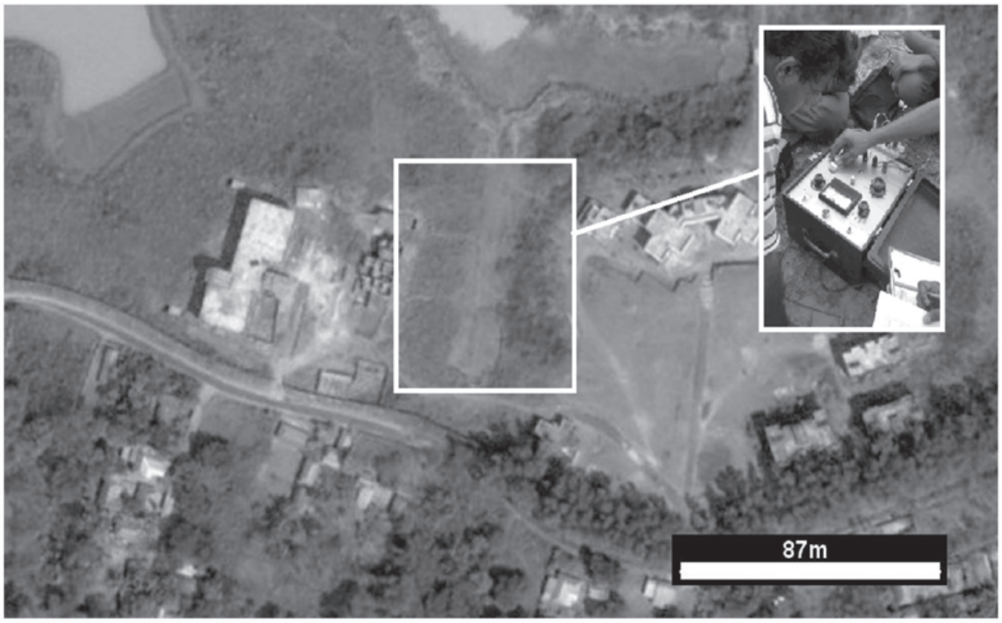

Figure 1. Environs of the selected slope area.

Table 1. Reading Obtained by SRM 4-Pin Method

sampling station distances (a) in Metres	Range	'R' obtained from recorded data	Calculated resistivity (ρ=2лaR) of soil in Ωm	Remarks
1	X10	11.8	74.104	Soft with sandy and clayey character, comparatively compact. Organic matter comparatively high. This soil is characterised by fine to medium particles.
2	X10	13.3	83.524	
3	X10	8.9	55.892	
4	X10	3.9	24.492	Very soft with sandy character. Low organic matter. Coarse to mixed texture has been observed and compactness of the soil is is less.
5	X10	3.9	24.492	
6	X10	4.4	27.632	

Here, π =6.28; a=1

of resistivity survey was applied. Total 6 stations (1m interval) were surveyed from the base of the slope (Table1). Profile of the selected slope was drawn by abney's level.

Digital indexing in grey scale:

One of the main focuses of the study is to develop the digital index of soil within greyscale. In digital format grey scale or radiometric scale (8 bit) digital number (DN) values vary from 0 to 255 bins. Displayed images of this sort are typically composed of shades of grey, varying from black at the weakest intensity (DN value=0) to white at the strongest intensity (DN value=255). Normally grey scale images are very commonly used in medical science and remote sensing. In remote sensing greyscales or radiometric images are used to assess many physical features of the earth. Whithe & El Asmar (1999); Frazier & Page (2000); Yanli (2002); Marfai (2003) and Bagli & Soille (2003) used radiometric resolution for assessing various physical characters of the earth surface. Recently

Marfai et al., (2008); Dey, Debbarma & Sarkar (2008c), Dey, Debbarma & Sarkar (2009a) and Dey, Sarkar & Debbarmal (2009b) successfully used 0-255 DN values in greyscale for surface analysis. At micro or nano level, greyscale also has been used to identify the mineralogical type and micro-fabric of the sediment depositions (Dey et al, 2009c; Dey et al, 2009d; Dey et al, 2009e; Dey et al, 2009f). Thus in the recent period of advanced soft computing from multi-spectrum data set, radiometric scale still has relevance in geophysical research.

In this experiment the present authors used the concept of grey scale within 0 to 255 values for digital indexing the soil resistivity of present area. Since the highest soil resistivity of soil is measured 83.524 by the instrument reading, 84 was considered as the maximum resistivity for digital indexing (Fig.2). The calculation was done for preparing the index within back to white in grey scale by the following formula:

$$R_C = \frac{\text{Max resistivity}}{\text{Total number of bins}} \text{ X } \begin{matrix}\text{Numer of bins}\\ \text{between corresponding}\\ \text{and lowest bins}\end{matrix}$$

Where, R_C = Resistivity level in measured greyscale

Micrography of soil samples:

Soil samples were collected from every survey points for micrographic test. All the samples were dried and tested under fixed reflective light. In this case a simple optical microscope was used with X10 objective and X10 eye lens. Images were prepared by 12.0 mega pixel digital camera (resolution 3000X 4000, 12.0 mp 3:2; ISO speed 3200; exposure time 1/80.00; colour space sRGB; max aperture f/3.29). The colour images were saved in grey scale to experiment brightness-contrast operation on those images which is suitable for detecting high reflective objects or particles (Dey et al, 2010). In the present work contrast and brightness of the images were increased up to maximum point (100%) which is 50% greater than normal image. The reflectivities of the various particles are differentiated by white to black colours bins. Four types of objects were identified by this methods namely white quartz (white) yellow sand (light grey) sandy clay (deep grey) and clay (black).

The digital colour image was enhanced and some selected parts of the images were converted to 'glow scale' mode to assess the geometric shape of the particles. The glow scale was converted to grey scale for final analysis.

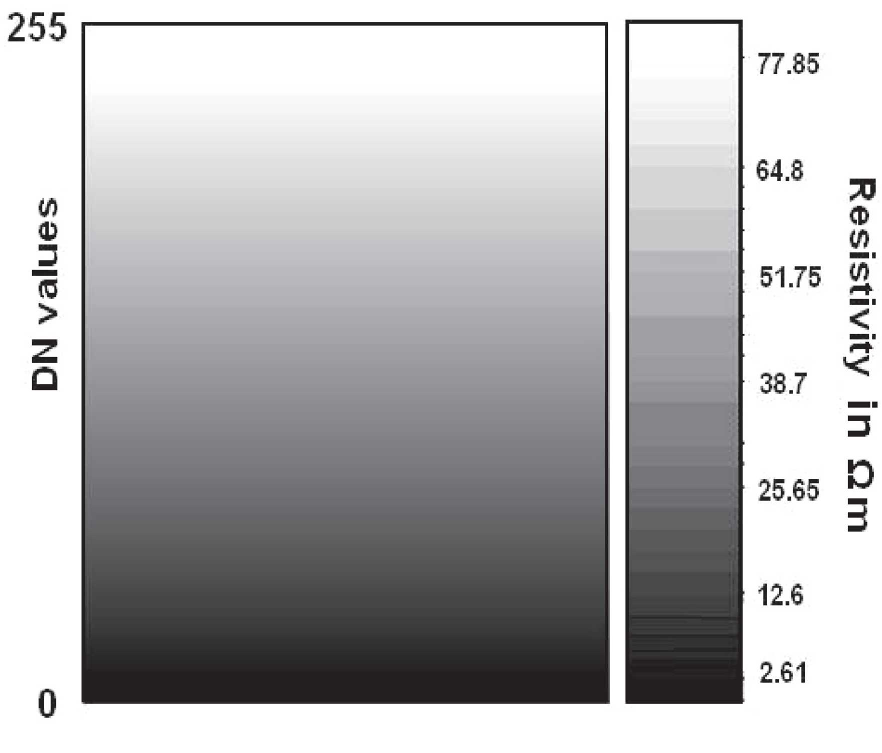

Figure 2 Greyscale in digital format and resistivity index.

RESULTS AND DISCUSSION

Electrical conductivity and soil characters:

Electrical record: On the first reading point or at 1m the electrical conductivity of the soil was recorded 11.8 Ù while on 2m conductivity increases up to13.3 Ω . On 3m point it decreases at a remarkable rate 8.9 Ω. On this point the compactness of soil is very low and it is characterized by coarse sand with very little clay. The upper parts (4m 5m and 6m) of this small slope soil electrical conductivity has been observed very low around 3.9Ω to 4.4Ω. This is a very immature dry sandy soil without clay composition. Medium to coarse sand particles are very prominent in the soil of this part (Fig.3a).

Soil character: A micro-architecture study on the collected soil samples shows general character and geometric shapes of particles (Fig.3b). Since the area of data generation is very small only 6m in length, very minor variations in mineralogical characters or grain size has been observed. Quartz, silica, clay and occasional lignite and gypsum are very common mineral compositions in the soil of this area. The organic layer is very thin. At 1m point the soil characterised by fine to medium size particles. Round to sub angular shapes of the particles have been found on this spot. The second sampling point (2m) is also marked by fine to medium size particles. Sub round or round particles are very common in this sample. Coarse to medium sands have been found at 3m point which is characterised by round and sub round particles. The first two samples are comparatively compact in character with higher percentage of clay and sandy clay than the third sample which was collected at 3m point.

The last three samples are marked by soft and sandy characters. These are less compact soil composed by coarse particles. Collected sample from 4m point shows coarse particles. The particle shape of this sample varies from sub round to sub angular. At 5m point the soil is characterised by very coarse angular and sub angular particles. Some rounded large particles were also found in this sample. The sample from the last point (6m) shows a mixed type of grain size and shape. In this sample very sharp angular, sub round and round shaped particles were observed.

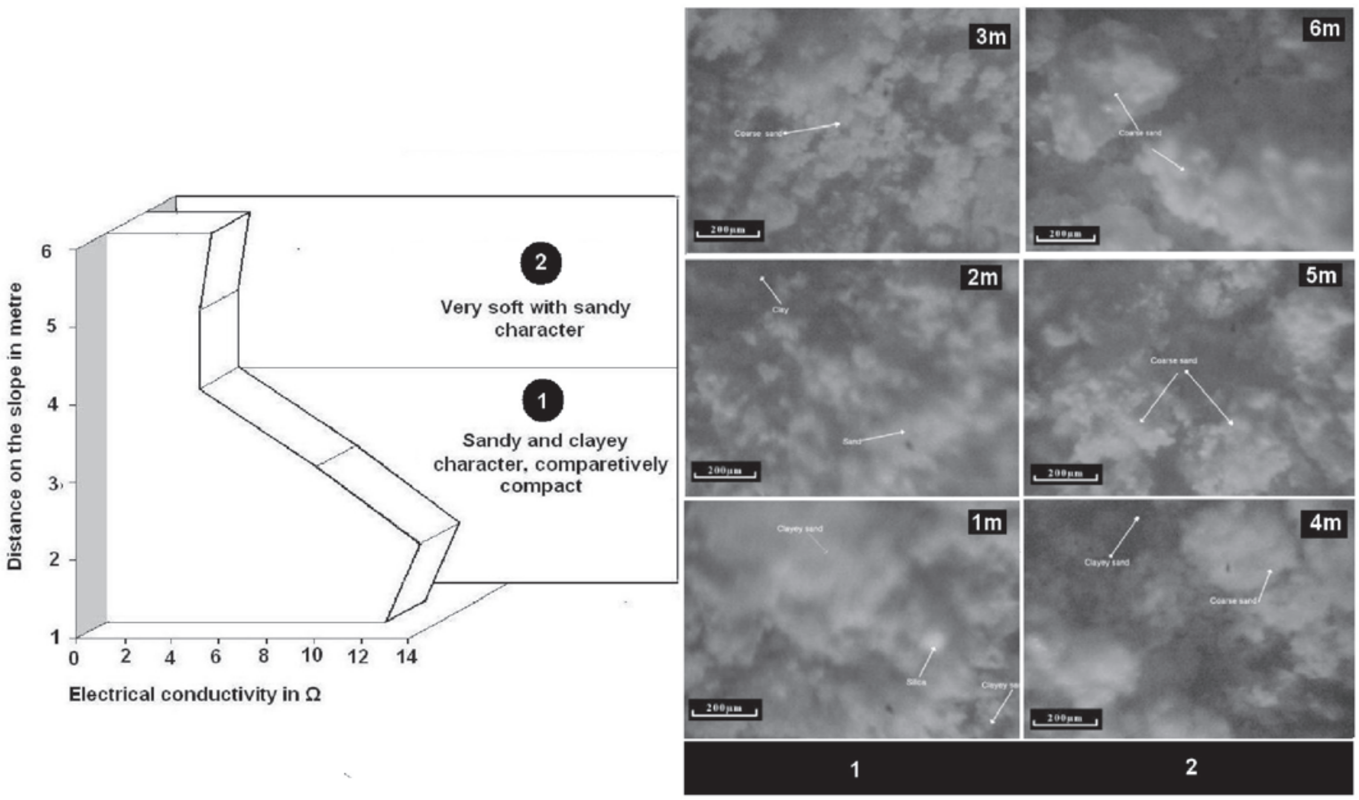

Figure 3a. Electrical conductivity of the soil and types of grain patterns (optical microscopic view, scale bars show 200μm) of the surface soil on the reading points.

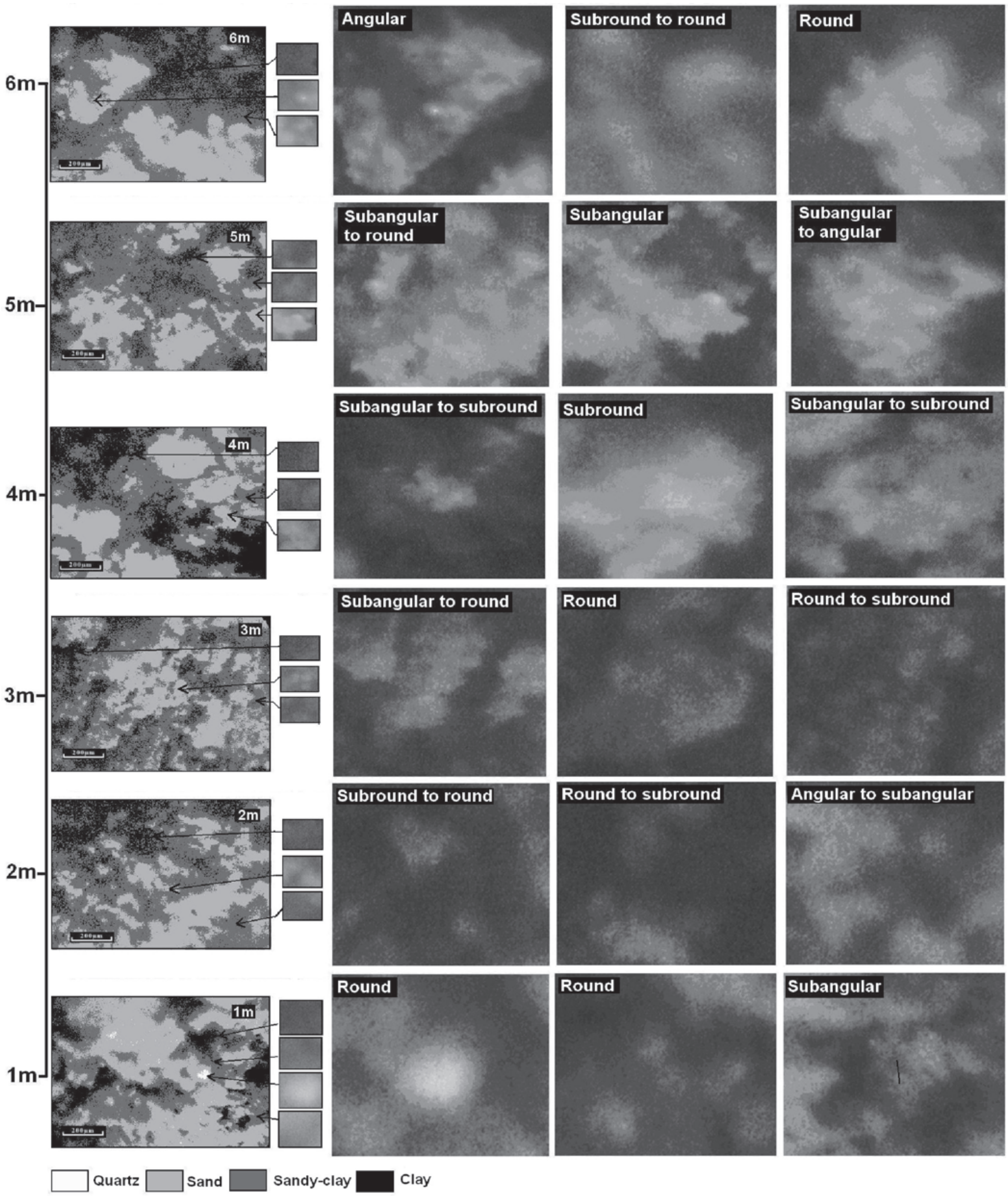

Figure 3b. Maximum contrast-brightness showing the general microstructure of the samples and glow images (grey scale) showing some specific geometric shapes of particles.

Slope character and vegetation cover:

This area is covered by mixed vegetations like *Cynodon dactylon* (locally known as Durbaghas; family: Gramineae), *Lantana camara* (family: Verbenaceae), *Calamus tennis* (locally known as Bet; family: Araceae), *Acacia Arabia* (locally known as Babla: family: Fabaceae or Lequminosa) and *Dracaena spicata (*family: Liliaceae). The studied slope is not only characterised by high level plant diversity, but also a remarkable variation in density of vegetation cover has been observed within very short distance which is influenced by the slope condition. The general condition of slope of this area is very high and varies from 5Ω to 30Ω.From 1m to 2m distance the slope angles varies from 10Ω to 8Ω and dense to very dense vegetation cover is found in this part. Between the second point (2m) and the third point (3m) slope angle is 10Ω but due to change of elevation density of vegetation cover decreases. From 3m to 4m point the slope become very steep and it decreases by 5Ω toward the opposite direction and in these part dense grasses with very scattered shrubs are found. After the 5m point the slope become very steep (>30Ω) up to 6m point and density of grass cover decreases remarkably.

Plant diversity and small area variation of soil resistivity:

The penetration of roots of the vegetation influenced to develop the organic matter in the soil. Thus the soil has become mature and resistivity in the lower part (up to 2m) varies 74.104 Ωm to 83.524 Ωm. Within 3m to 4m the resistivity goes down to 55.892 Ùm. Only grass covers are found within 4m to 5m and 5m to 6m points. So the organic matter in this part is very less and the soil is not mature. In these parts mostly dry coarse particles are found with very minimum organic content. Resistivity of soil is also very low in these parts and it was measured below 30 Ωm from electrical recording. All the measured resistivity was assigned in the greyscale index to understand the variation of geophysical character of soil within 6m distance (Fig.4).

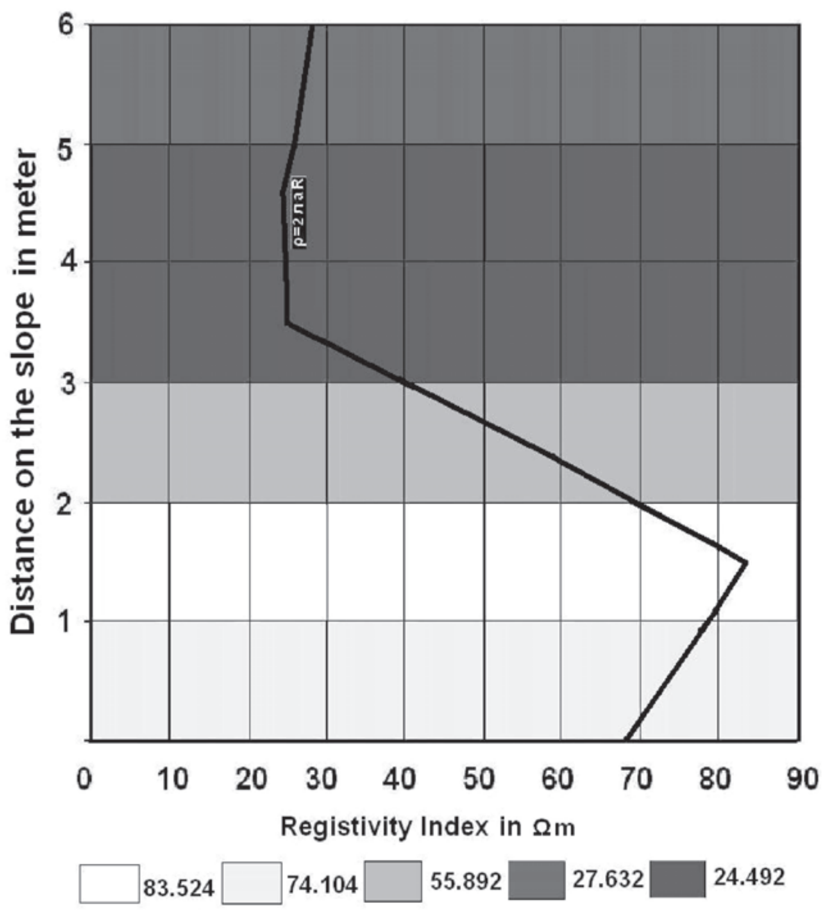

Figure 4. Resistivity graph and the assigned index in greyscale.

CONCLUSIONS

Impact of vegetation cover on soil is a very common issue in soil science but in most of the literature it is discussed in a generalized manner. In many scientific texts large scale influences of vegetation cover on chemical and physical properties of soil are described but the affect in a small area is not properly assessed. But from scientific point of view small area features cannot be ignored as they are the integral part of solid earth and able to influence on wide range change under specific conditions (Dey, 2005). The present study shows that though the mineralogical character of the studied soil profile is similar but vegetation cover plays a vital role for changing the geophysical character of soil within a very small area. Of course the surface slope plays an important role for micro-zonal level distribution and pattern of vegetation cover which has a further impact upon physical character of soil. Surface slope angles control water and temperature distribution in soil and suitability of penetration of plant roots. As a result of that soil resistivity varies 59.032 Ωm within only 6m area (Fig.5). This range is very remarkable from geophysical point of view because of the length of the area. The experimental part of the present study is also satisfactory at this level as it shows that digital indexing within greyscale can be a very suitable method for imaging short distance variations of soil geophysical character. It is very simple and easily applicable for the visual expression of geophysical characters. Micro-zonal mapping of soil or rock character may be the advanced version of further application of this greyscale indexing for in depth soil research.

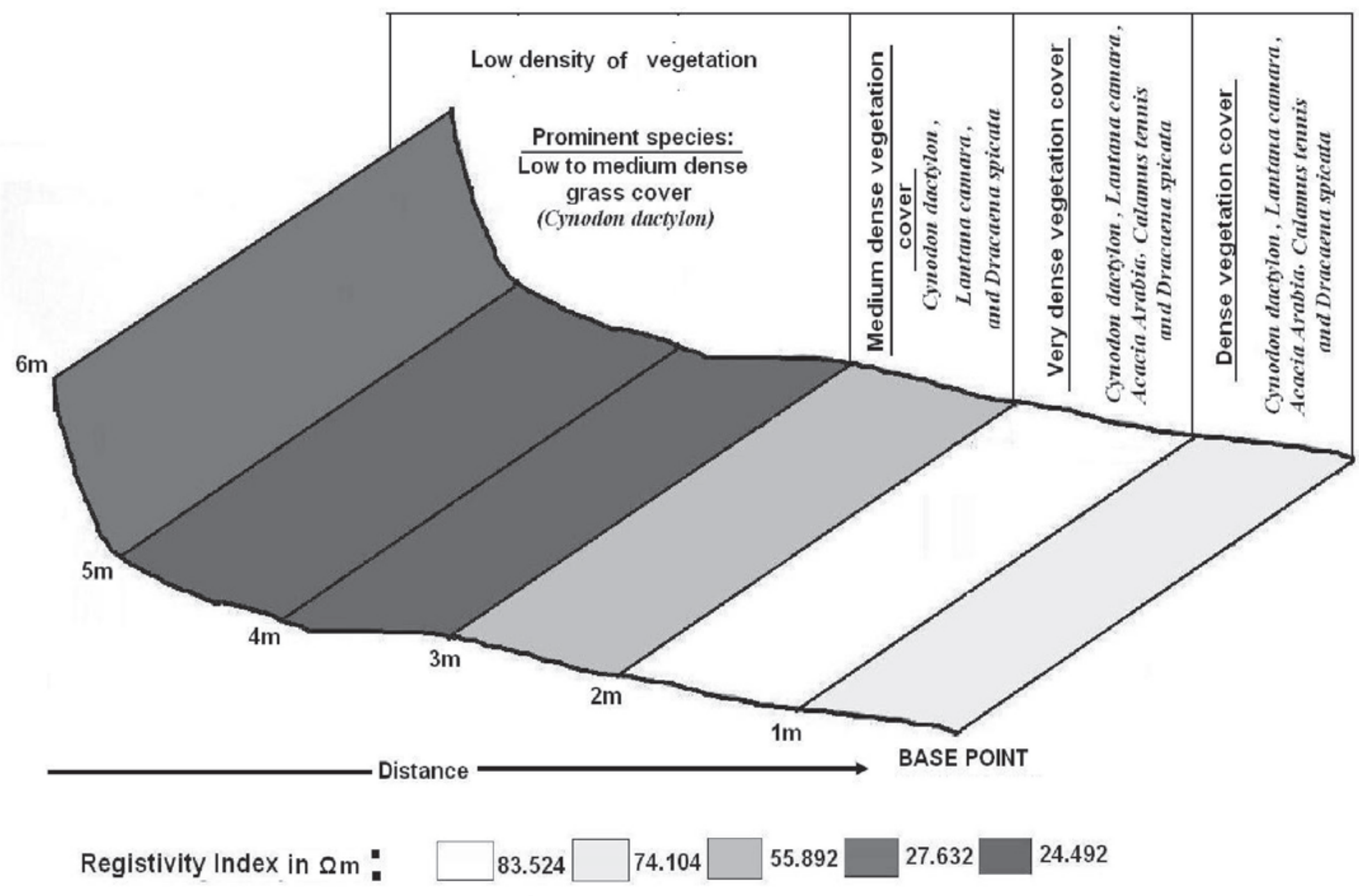

Figure 5. Stretched profile shows the variations of slope angle, vegetation cover and resistivity of soil within 6m distance.

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