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Development of soil line and vegetative indices using spectroradiometer

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■ **ABSTRACT :** One of the major applications of remote sensing in environmental resources management and decision making is the detection and quantitative assessment of soil and vegetation. Operational monitoring of vegetative cover by remote sensing currently involves the utilisation of vegetation indices (VI), it is the function of the reflectance in red (R) and near-infrared (NIR) spectral bands. Although many variations exist, most of them are the ratio of the reflection of light in the red and NIR sections of the spectrum to separate the landscape into water, soil, and vegetation. The present research was conducted for development of soil line and vegetation indices ratio vegetative index (RVI) and soil adjusted vegetative index (SAVI) and to develop relationship between vegetation indices and bulk density. Four soil series namely Gulvanch, Targaon, Rahuri and Pather series were used in the study. The soil line, a linear relationship between bare soil reflectance observed in two IR and NIR waveband which is widely used for interpretation of remotely sensed data. Soil line based vegetation indices are introduced which may be used for assessment of water use, plant stress, crop production and requires knowledge of external environment. Slope, intercept of soil line were developed for four different series and used for estimation of vegetative indices. The maximum slope for soil line was for Targaon series followed by Rahuri, Pather and Gulvanch series. Relationships between bulk density and vegetation indices (RVI, SAVI) were developed by curve fitting method, linear function was most suitable function. Relationship between vegetation indices (SAVI and RVI) and bulk density was developed which can be used for determination of physical properties from remotely sensed data.

■ **KEY WORDS :** Reflectance, Soil line, Vegetation indices

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The soil and water are most precious natural resources for sustained economic development in any country. Water resources and environmental management is essential for sustaining quality of life on earth. Modeling and monitoring of suspended matters in water bodies is a difficult task because of many influencing factors. Monitoring of suspended sediment concentration (SSC) in reservoir, river, coastal waters and estuaries is imperative. Remote sensing technology holds potential for monitoring and estimating suspended sediments in surface water. The soil type is the main factor of variation of the soil line, and hence, a different soil line should be defined for each soil series. Soil reflectance is likely to change from place to place, depending on soil type.

Four different series *viz.*, Gulvanch series, Targaon series, Rahuri series and Pather series from central campus of M.P.K.V., Rahuri were used for the research.

In this work, the basis of the soil line was investigated using a soil reflectance, measured by HR 1024 Spectroradiometer. Twenty levels of suspended sediment concentration (50 to 1000 ml) were created in large tank filled with 7510 liters of clear water. The possible factors of variations of the soil line were analyzed through a laboratory experiment where both spectral and directional reflectance variations of few contrasted soil types and surface aspects were measured. The soil line concept is a key concept in understanding the functionality of VI. This is the linear relation between the reflectance R and NIR that best fits the values measured for bare soils with varying amount of moisture, roughness etc.

Several Scientist worked on soil line concept and development of vegetation indices. Huete (1988) studied soil adjusted vegetation index The SAVI was found to be an important step toward the establishment of simple "global" models that can describe dynamic soil-vegetation systems from remotely sensed data. Rundquist *et al.* (2000) studied vegetation and soil lines in visible spectral space. The vegetation and soil lines define a two-dimensional spectral construct within which canopy reflectance, regardless of vegetative fraction, may be located. Banman (2001) worked on remote sensing of vegetation and soil. As a general characteristic, active vegetation will absorb a high percentage of the available visible red wavelengths which are used in the photosynthesis process, while they will tend to reflect most of the harmful NIR radiation. Gilabert and Melia (2002) studied a generalized soil adjusted vegetation index (SAVI). VI (including GESAVI, NDVI, PVI and SAVI family indices) were computed and their correlation with LAI for the different soil backgrounds was analyzed. Huete *et al.* (2010) worked on soil line influences. The results indicate the validity of our analytical approach for the evaluation of soil line influences and the applicability for adjustment of VI errors using external data sources of soil reflectance spectra.

■ METHODOLOGY

The soil line is developed through simple regression of IR and NIR soil reflectance values at the various stages of dry and wet condition. A sample plot with high soil moisture content will display a low reflectance (large brightness factor value). Soil line is useful for determination of various types of vegetation indices and interpretation of remotely sensed data. Soil line parameters were used for interpretation of remotely sensed data and determining vegetation indices. Reflectance data were collected in dry and under wet condition of soil with HR 1024 Spectroradiometer. Vegetation indices were developed by soil line parameter. Ratio vegetative index (RVI) was developed by method given by Pearson and Miller (1972). Soil adjusted vegetative index (SAVI) was developed by method given by Huete (1988). Relationship between vegetation indices and bulk density was developed with curve fitting method:

$$\mathbf{RVI} = \frac{\mathbf{NIR}}{\mathbf{R}}$$

where,

RVI-ratio vegetation index, NIR-Near infra-red reflectance, R-Red reflectance.

Relation between bulk density of soil and RVI was developed using the data points for each of the soil series.

The soil adjusted vegetation index (SAVI) was developed as a modification of the normalized difference vegetation index (NDVI). The SAVI is structured similar to the NDVI but with the addition of soil brightness correction factor. The SAVI can be computed using the following equation :

$$\mathbf{SAVI} = \frac{\mathbf{NIR - R}}{\mathbf{NIR + R + L}} \times (\mathbf{1 + L})$$

where,

L- Soil adjusted factor, L=0, in very high vegetation regions, L=1, in areas with no vegetation.

■ RESULTS AND DISCUSSION

The results for all soil series showed the results as tabulated in Table 1.

For the development of the soil line the observations were recorded for the completely saturated soil and dry soil sample *in situ* condition. The dry soil sample showed more reflectance than wet soil. Soil line is developed from dry and wet soil reflectance data of different series. The plot of red vs near Infra-Red wavelength is plotted for these two condition which gives soil line. From the set of observations, the soil line is developed for all four soil series as shown in Fig.1 to 4.

The result obtained for all soil series showed the result as tabulated in Table 2.

Soil line based vegetation indices includes soil slope, intercept and parameter introduced for different series in order to remove the soil background for example

Table 1 : Physical properties of four soil series

Soil series	Textural classification			Textural class	Bulk density (g/cm^3)	Dry density (g/cm^3)	Plasticity index (%)
	Sand (%)	Silt (%)	Clay (%)				
Gulvanch	37.28	28.99	33.73	Clay loam	1.674	1.490	16.45
Targaon	26.15	24.82	49.03	Clay	1.331	1.181	31.31
Rahuri	28.79	31.26	39.95	Clay loam	1.508	1.408	20.26
Pather	20.63	25.40	53.97	Clay	1.582	1.386	33

Table 2 : Slope and intercept for four series

Soil series	Slope	Intercept
Gulvanch	0.8531	6.0216
Targaon	1.8088	-3.1091
Rahuri	1.7497	-5.2659
Pather	1.5102	-0.3065

Table 3 : RVI and SAVI

Soil series	NIR	IR	RVI	SAVI
Gulvanch	22.69	24.95	1.100	0.093
	19.75	22.96	1.163	0.147
	19.71	22.62	1.148	0.134
	19.15	22.32	1.166	0.149
	20.23	23	1.134	0.125
Targaon	8.73	12.47	1.428	0.337
	9.05	13.04	1.441	0.346
	6.38	10.18	1.596	0.433
	9.98	14.36	1.439	0.346
	10.92	15.99	1.464	0.363
Rahuri	12.88	16.43	1.276	0.234
	11.2	14.27	1.274	0.232
	11.74	15.13	1.289	0.243
	11.85	15.02	1.268	0.227
	11.93	15	1.258	0.220
Pather	8.4	11.72	1.396	0.314
	6.87	10.24	1.491	0.372
	6.63	9.92	1.496	0.375
	6.93	10.41	1.502	0.380
	8.24	12.15	1.474	0.366

Table 4 : Relationships between bulk density and RVI for four soil series

Soil series	Relationship	R^2
Gulvanch	BD=3.7534 RVI-2.6199	0.98
Targaon	BD=05949 RVI+0.4535	0.83
Rahuri	BD=8.1538 RVI-8.88	0.95
Pather	BD=1.3517 RVI-0.4077	0.93

Table 5 : Relationships between bulk density and SAVI for four soil series

Soil series	Relationship	R^2
Gulvanch	BD= 4.4754 SAVI+1.0934	0.98
Targaon	BD= 1.0933 SAVI+0.9327	0.87
Rahuri	BD= 10.117 SAVI-0.8327	0.84
Pather	BD= 2.0747 SAVI+ 0.8324	0.88

humus, root and rock which can alter the vegetation spectral, useful for classification of soil.

The bulk density plays a role on the reflectance of the soil to find out the relationship between RVI and bulk density. The relationship between bulk density and RVI is shown in Fig.5. All the plots showed the linear relationship between the bulk density and RVI (Table 3). The relationship observed for all soil series in given Table 4.

As there is strong relationship between bulk density and SAVI hence, relationship for all four soil series are developed and tabulated in Table 5 and Fig. 6.

Summary and conclusion :

Soil line was developed from dry and wet condition

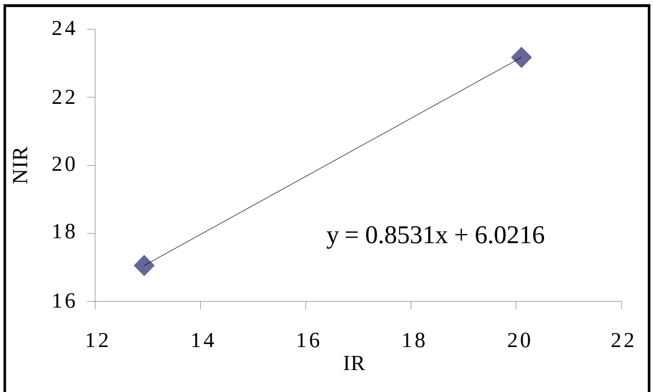

Fig. 1 : Soil line for Gulvanch series

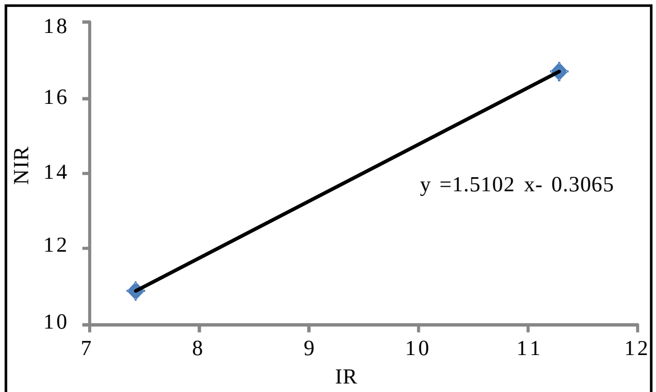

Fig. 4 : Soil line for Pather series

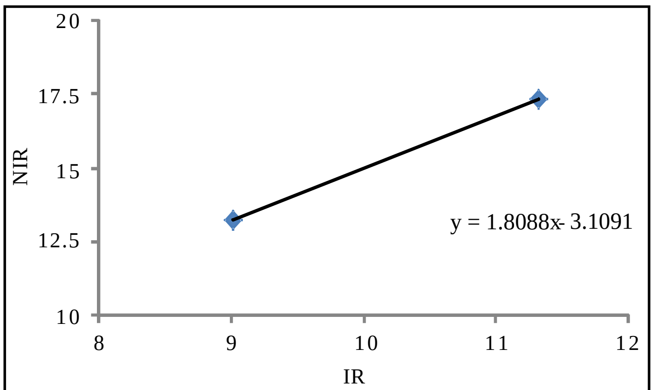

Fig. 2 : Soil line for Targaon series

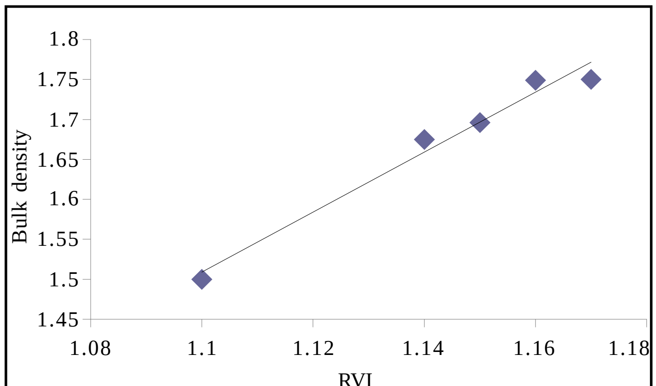

Fig. 5 : RVI vs bulk density for Gulvanch series

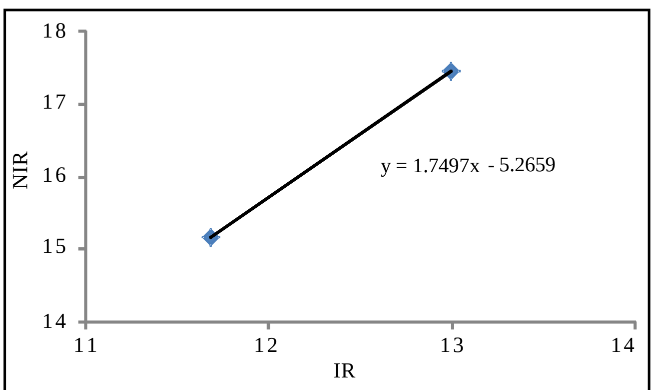

Fig. 3 : Soil line for Rahuri series

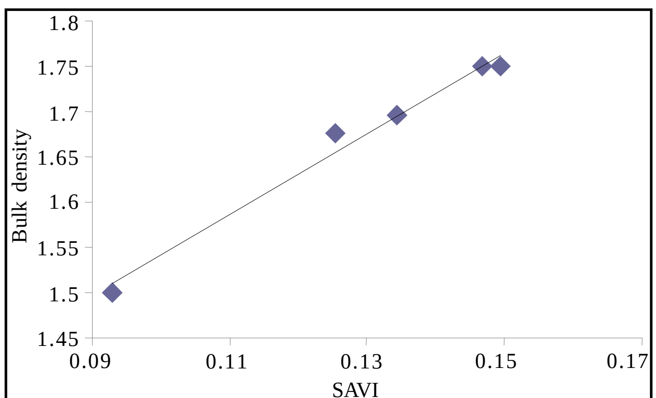

Fig. 6 : SAVI vs bulk density for Gulvanch series

of soil series on field. Dry soil reflectance was more than wet soil reflectance. Slope and intercept of line were determined and soil line was developed with help of this slope and intercept. The maximum slope for soil line was for Targaon series followed by Rahuri, Pather and Gulvanch series. Relationships between bulk density and vegetation indices (RVI, SAVI) were developed by curve fitting method, linear function was most suitable function. This Relation is useful for determining the physical property e.g. the bulk density of the soil present in the water body can be estimated and this property of sediment can help us to recognize the sediment type present in the various layers of the water. The vegetation index introduced in this work needs a prior knowledge of the reflectance data and the soil adjustment factor to be suitable for operational monitoring of vegetation from remotely sensed data. Linear relationship was found between bulk density and vegetation indices.

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