



Signature capture of red soil patches and their acidity-A case study of Banka district, Bihar, India

Binod K. Vimal, Rajkishore Kumar*, C. D. Choudhary, Sunil Kumar, Rakesh Kumar, Y. K. Singh and Ragini Kumari

Department of Soil Science and Agricultural Chemistry, Bihar Agricultural College, Sabour-813210, Bhagalpur, Bihar, INDIA

*Corresponding author. E-mail: kishoreraj1333@gmail.com

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Abstract: Colour in soils as well as other object is the visual perceptual property which is perceived by human eye. They are governed by spectrum of light corresponding to wavelength or reflected energy of the material. Developed model for soil acidity is based on visual interpretation, principal component and spectral enhancement techniques by using of the satellite image (IRS LISS III, 2014). In this context, red soil patch is much sensitive in red spectral band comparison to green and blue spectral bands and perceived as red tone by human eyes but same soil patch appears green in false colour composite (FCC) image of NIR (0.70-0.80 μ m), Red (0.60-0.70 μ m) and Green (0.50-0.60 μ m) bands. The maximum coverage of red soil patches having low pH < 6.5 (1:2.5) was recognized in 44.07 per cent of the total geographical area (3019.56 sq.km) under Banka district. Maximum red soil patches having their acidity were recognised in Katoria (18.56%), Chanan (15.15%), Bounsi (10.44%) and Banka (9.92%) blocks. Overall results indicated that variation of tone in different bands helps for the separation of red soil patches.

Keywords: NIR band, RS-GIS, Satellite image, Spectral signature

INTRODUCTION

The soils are valuable natural resources which are directly or indirectly associated with agricultural activities. Acidity or alkalinity in soils, affect towards nutrient supply in the plant. If a soil is too sour or too sweet, plants cannot take up nutrients like nitrogen (N), phosphorus (P) and potassium (K) (Buckman *et al.*, 2002). There are four factors that influence signature of soil viz. mineral composition, organic matter, soil moisture and texture (Ben-Dor 2002). Generally, red soils appear near hilly terrain with the presence of iron oxide and they have peculiar tone from surrounding. Wide range of soil colour; gray, black, white, red, brown and yellow is influenced by the content of organic matter, presence of water and oxidation state of iron and magnesium. Iron oxides, clay minerals and soil colour can be measured directly from the spectra (Viscarra Rossel *et al.*, 2009). When light hits objects i.e. soil, water, vegetation some of the wavelengths are absorbed and some are reflected, depending on the materials characteristics (Panda, 2009). In this context, reflected energy from different materials in the terms of different spectral wavelengths is received by satellite sensors and converted into pictorial view. In continuation of sensor based technology, remote sensing and Geographic Information System (GIS) techniques are widely accepted as most reliable, rapid and cost effective for collection of data on status of natural re-

sources over large areas (Saxena *et al.*, 2000). Remote sensing data have been used for soil classification, soil resources mapping (Ray *et al.* 2002, 2004), soil moisture assessment (Engman and Chuhan 1995) and soil degradation (salinity) and mapping (Metternicht *et al.* 2003). Examples of some factors that most commonly affect the soils and soil properties (*s*) as described by V.V. Dokuchaev in Russia and others such as by H. Jenny in the U.S. are climate (*cl*), organisms (*o*), topography (*r*), parent material (*p*) and time (*t*) (Jenny 1941). Integrating these factors to express the dynamic nature of soil formation has been shown in the following equation provided by Hans Jenny. $S = f(cl, b, r, p, t)$. This equation puts forth the idea that for any specific soil property within a soil such as pH and clay content *etc.* (Brickley *et al.* 2010) that property is a function of soil forming factors, each being independent but working in unison to form unique soils in Banka district. Soil survey towards land use planning is an important part for the sustainability of agriculture practices. Soil resource inventory provides adequate information in terms of land form, natural vegetation as well as characteristics of soils which can be utilized for land resources management and development (Manchanda *et al.*, 2002). However, yellow or red soil indicates the presence of iron oxides and their colour associations are influenced by reflected or absorbed energy. Results showed a good correlation between the spectral reflectance from field measurements and

the spectral reflectance obtained from analyzing the satellite imagery (Hussien *et al.* 2014). Therefore, spectral variation over red soils provides an opportunity for the separation from surroundings. Signature capture of perfect tone or spectral responses of the target from satellite image is a researchable issue in RS-GIS domain. Keeping in view and to short out the problem, the present study was carried out for the spectral signature capture of red soil patches corresponding to soil pH under Banka district of Bihar.

MATERIALS AND METHODS

Study area: Banka district of Bihar, India was selected for the signature capture of red soil patches (Fig.1). It is situated in far south east of the State Bihar having geographical extension of 24°30' to 25°06'N and 86°30'E to 87°07'E. The eastern and southern border of the district coincides with district Godda of the state Jharkhand. In west and north east it touches Jamui and Munger district, respectively. The old district Bhagalpur is situated in the north side of Banka. The geographical area of the district is 3019.3465 km² having eleven blocks. Field survey was done during the month of February, 2014 and eight locations under red soil patches were selected with GPS reading for visual interpretation and image enhancement of the satellite image. Soil pH was analyzed as per the standard procedure by Jackson (1973) in the laboratory for the availability of acidity level in red soils.

Principal component analysis (PCA): The principal components process the spectral bands to derive a reduced number of parameters (dimensional reduction) and increase interpretability. Generally, processed maps are derived

from a statistical analysis of the input rasters which is processes under principal component. In principal component (PC) analysis, one can use the standard or selective analysis, the difference being that in the former, while in the later, only certain bands are chosen (Crosta and Moore, 1989). The principal components that contain spectral information about specific materials, as well as the contribution of individual original bands in relation to the spectral response of the materials of interest. Spectral Feature Fitting to create a similarity score to compare to all other soil samples within the spectral library (Spatial Analyst, <http://geol.hu/data/online> 2012). Principal Component Analysis (PCA) under spectral enhancement was done for the separation of red soil patches from surroundings. To achieve this target, IRS LISS III satellite image (spatial resolution 23.5m x 23.5m) during the month of March, 2014 and TNT mips (licensed version spatial related software) were used. Ground truth towards red soil patches under PCA analyzed image in different locations was done using GPS and toposheets. Statistical analysis was performed to optimize the number of spectral bands and spectral parameter to be used for estimating soil nutrient content for the unknown pixels of the image (Ghosh *et al.*, 2012). Details of methodology towards visual interpretation and spectral enhancement processes are being summarised in given flow chart.

RESULTS AND DISCUSSION

Healthy vegetation appears green due to high reflectance of green band comparison to blue and red bands

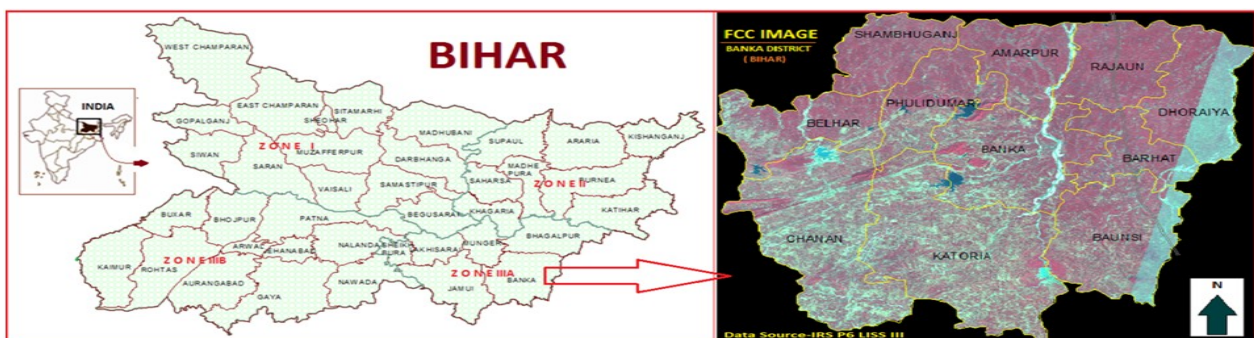
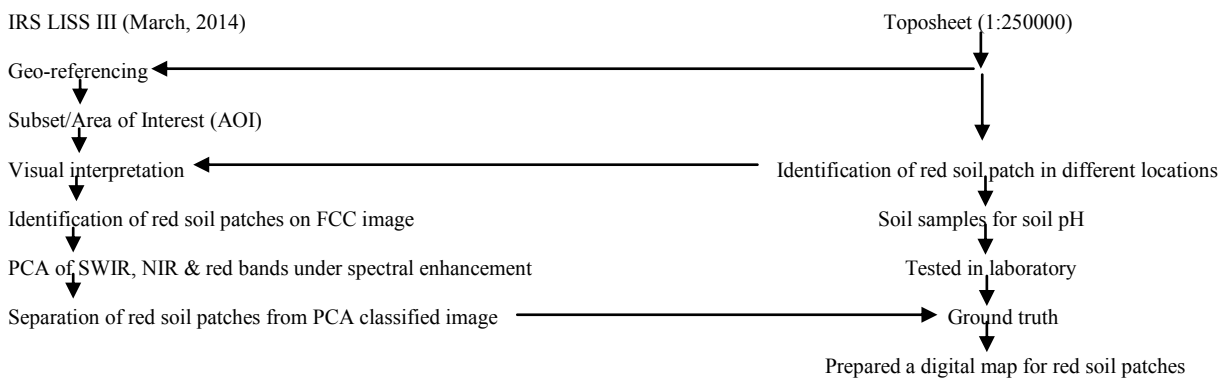


Fig. 1. Location map of the study area.

(Data Source-IRS LISS III, 2014)

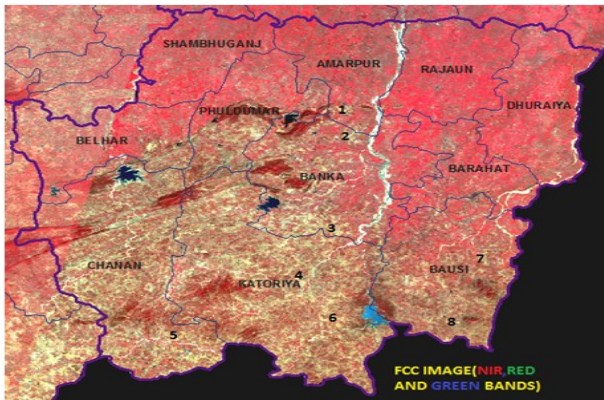


Fig. 2. False Colour Composite image.

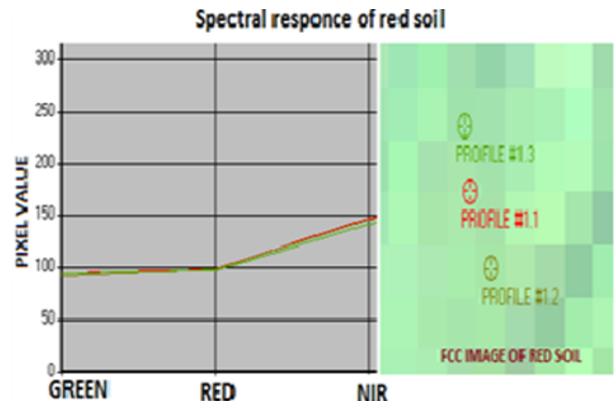


Fig. 4. Spectral response of red soil.

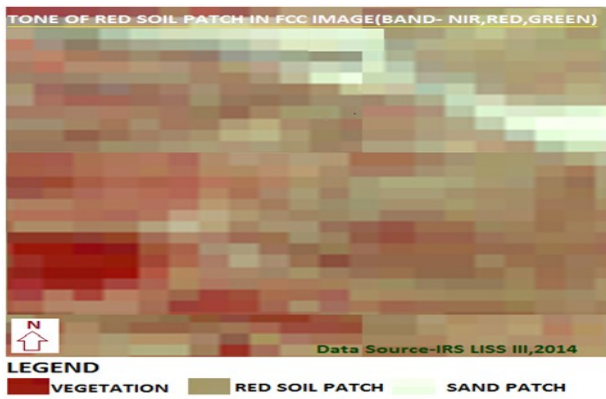


Fig. 3. Red soil patch in green tone.



Fig. 5. PCA image of red soil patch.

Table 1. GPS based locations surveyed for spectral signature towards validation of red soil patches and soil pH (1:2.5), (Locations are plotted in serial number on FCC image, Fig. 2).

S.N.	Latitude	Longitude	Soil pH (1:2.5)
1	24°57'42"N	86°53'25"E	5.72
2	24°55'00"N	86°53'45"E	5.91
3	24°47'33"N	86°52'46"E	5.66
4	24°42'48"N	86°50'00"E	5.83
5	24°31'50"N	86°26'28"E	5.73
6	24°39'27"N	86°52'10"E	5.71
7	24°44'59"N	87°2'33"E	5.85
8	24°38'57"N	87°00'41"E	5.55

Table 2. GPS based locations surveyed for spectral signature towards validation of red soil patches and soil pH (1:2.5), (Locations are plotted in serial number on PCA image, Fig.5).

S.N.	Latitude	Longitude	Soil pH (1:2.5)
1	24°57'58"N	86°53'12"E	5.81
2	24°52'46"N	86°51'54"E	5.76
3	24°48'20"N	86°48'32"E	5.64
4	24°46'00"N	86°49'14"E	5.83
5	24°42'26"N	86°49'14"E	5.81
6	24°42'26"N	86°38'12"E	5.84
7	24°40'48"N	86°48'39"E	5.71
8	24°36'09"N	86°43'43"E	5.82
9	24°36'42"N	86°48'45"E	5.92
10	24°37'53"N	87°02'21"E	5.75

Table 3. Total Geographical area, covered with red soil patches in different blocks of Banka district.

Different CD blocks under Banka district of Bihar	Geog. Area (km ²)	Area under red soil patches (km ²)	Percentage of red soil patches
Sambhuganj	179.75	3.60	5.95
Amarpur	186.25	7.45	6.17
Rajoun	197.51	5.93	6.54
Dhoraiya	234.14	14.05	7.75
Barahat	147.28	4.42	4.88
Banka	299.64	239.71	9.92
Phullidumar	205.04	123.02	6.79
Belhar	236.58	123.02	7.83
Chanan	457.47	416.30	15.15
Katoriya	560.57	521.33	18.56
Baunsi	315.33	214.42	10.44
Total	3019.56	1673.25	100

(Lillesand *et al.*, 2005) means red objects appear red in same RGB band combination. When light hits the red soils, some wavelengths (energy) are reflected and received by satellite sensors. If the radiation arriving at the sensor is measured at many wavelengths, over a sufficiently broad spectral band, the resulting spectral signature, variation or simply spectrum, can be used to identify the materials in a scene and discriminate among different classes of material (Gary *et al.*, 2003). As per reporting by Lillesand *et al.*, (2005) healthy vegetation appears red in False Colour Composite image (layers of NIR, red and green bands). It means, red soils or objects are perceived green in same band combination on computer monitor (Fig.3). Spectral response of red soil patches was observed high in NIR and red bands comparison to green (Fig.4). Distinct variations in spectral reflectance show reconciled counter variation in major soil orders across large landscapes. It may be noted that the reflectance characteristics varies across soil types. As expected, darker *Vertisols* of Karnataka show minimum soil reflectance at all wavelengths compared the lighter *Inceptisols* of Uttar Pradesh (soils of Agra region) and *Aridisols* of Rajasthan (soils of Jodhpur region); deep red *Alfisols* of lateritic origin show intermediate reflectance values. In this regard, the different spectral bands and VIS spectral features generally account for the electronic transitions (ET) associated with the iron-bearing minerals such as hematite and goethite (Viscarra Rossel and Behrens, 2010) is directly auto correlated with red soils patches (*Alfisols*) of Banka district in Bihar. To identification of those pixels which are associated with green colour corresponding to red soils, GPS reading (latitudes and longitudes) from different locations was taken and plotted on FCC image (Fig.2 and table 1). All locations towards red soils were matched on green pixels (Fig.3). Kadupitiya *et al.*(2010) reported that the Hyperion data were used to estimate soil fertility parameters viz., OC, available N, available P and available K and soil physical properties such as soil texture, bulk density, particle density, hydraulic conductivity (K_s) using DRS (diffuse reflectance Spectroscopy) by pre-processed soil samples and pH to soil acidity. In continuation of research finding, PCA technique was applied for the separation of green associated pixels using spectral enhancement of NIR, Red and green bands corresponding to pH variation. Fe content in red soils patches at Banka district has a significant role in defining the shape of the reflectance spectra due to the ET of Fe^{2+} and Fe^{3+} present in the soils as iron oxides or impurities. The verified spectral reflectance of the soil increases exponentially with the decrease in particle size and the increment was found to be rapid below 0.4 mm. In the quest of red soil patches, spectral reflectance decreases with the increase in particle size and spectral reflectance gave the boost up to validate this model. The similar work has supported by Bowers and Hanks (1965) in respect of

reflection of radiant energy from soils. The Principal Component Analysis (PCA) known as a linear transformation technique related to Factor Analysis. It is a set of image bands which is given in as raster input file in software and produces a new set of images, known as components, which are uncorrelated with one another and are ordered in terms of the amount of variance they explain from the original band set. Spatial related softwares viz., TNT mips, Erdas Imagine and Envi provide a platform for the processing of multispectral image (raster) into PCA image. Pixels corresponding to red soils and their purity were enhanced and separated from surrounding which is shown in cyan colour (output image) under PCA classified image. Ground truth was done towards cross checking of assigned red soils on PCA classified image corresponding to the ground using GPS receiver and toposheet. The pH values of the red soils (tested in the laboratory) were marked in acidic range which were plotted on same cyan colour in PCA classified image even samples of the red soils with latitudes and longitudes position from ten new locations were collected, analyzed and laboratory report of analysed soil samples were cross checked on PCA classified image (Fig.5) and summarized in Table 2. Similar result was found in respect soil pH and shows the clear cut gap in grey values of colors and the ranges of soil pH and pH index values which varies from 7.30 to 7.50 and 0.0070 to 0.0261, respectively in deep brown color of Nathnager at Bhagalpur district in Bihar (Vinay *et al.* 2013). Similar type of work has done in tropical soil characteristics to measuring the of narrow band spectral models (Demattê *et al.* 2010) in country level mapping of soils (Viscarra Rossel *et al.* 2010) in Australia. Finally, pixels' counting process was applied for the calculation of geographical area having red soil patches under different blocks (Table 3). Results indicated the diversity of possible uses towards red soil properties and their features using remote sensing technique

Conclusion

This model is based on digital image processing technique under RS-GIS domain in which PCA technique has been applied for the signature capture of red soil patches from surroundings. To achieve this target spectral enhancement process was initiated by using the satellite images IRS LISS III, 2014 under ENVI - 5.1 spatial related software. PCA image indicated the clear cut demarcation of red soil patches from surrounding. Method of soil spectra collection in digital value was allowed for the conformation of soil spectra, in which specific spectral bands could be associated with soil acidity in respect of soil pH. Based on research finding, maximum coverage of red soil patches having acidity was recognised in Katoria (18.56%) consequently Chanan (15.15%), Bounsi (10.44%) and Banka (9.92%) blocks. Only 1673.25 km² (44.4%) of

the total geographical area (3019.56 km²) was traced out under red soil patches which are acidic in nature. Low coverage of red soil patches was traced out in Sambhuganj (5.95%), Amarpur (6.17%) and Rajaun (6.54%) block. Research findings may be helpful for red soil inventory and mapping.

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