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STUDY OF SPECTRAL REFLECTANCE CHARACTERISTICS OF VARIOUS GROUND FEATURES AROUND ROORKEE AREA INCLUDING DOON VALLEY

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ABSTRACT

Spectral reflectance studies based on signature measurement are carried out to determine the spectral response patterns of different earth surface features. For effective utilization of multispectral data acquired from satellite sensors, spectral reflectance characteristics of different features are needed to be known.

In this study spectral data were collected using a portable grating type radiometer at different wavelengths ranging from 0.40 to 1.02 μm. The data were collected on different dates, in Roorkee and its surrounding areas. The spectral reflectance for various features were measured in four spectral bands within the visible and near infrared wavelengths corresponding to Landsat Multispectral Scanner (MSS). An attempt was also made to compute and study various ratio values. The spectral reflectance characteristic curves were studied for various features from spectral reflectance values collected. In the end, a comparison of spectral response of various earth features have been made. Based on these studies most appropriate spectral range for identifying a particular feature type has been suggested.

1.0 INTRODUCTION

In remote sensing electromagentic energy is the means of detecting and measuring characteristics of earth features. Electromagentic energy includes light, heat and radio waves. Energy propagates in the form of electromagentic radiation (EMR) with the velocity of light from the source, directly through free space, or indirectly by reflection and reradiation to the remote sensor.

1.1 Energy Matter Interaction

Electromagentic energy that encounters matter, whether solid, liquid, or gas is called incident radiation. When Electromagentic radiation is incident upon the earth's surface it will tend to be either reflected, scattered, absorbed or transmitted by that surface. The proportion of energy in these processes will vary for different earth features, depending upon their material type and condition. The magnitude and extent to which each of these processes occures enables features to be differentiated from each other.

Scattering of the incoming Electromagentic radiation to the earth, and of the reflected Electromagentic radiation from the earth's surface, is caused by the presence of molecules of gases, dust and smoke particles in the atmosphere. In the upper atmosphere scattering called as "Rayleigh Scatter" is caused by the interacation of gas molecules which have diameter much less than the radiation wavelength. While scattering in lower atmosphere is due to interaction of dust and smoke particles.

In contrast to scattering, atmospheric absorption results in the effective loss of energy to atmospheric constituents. The gases like water vapour, carbon dioxide and ozone absorb electromagentic energy in specific wavelength bands and this governs which regions of the spectrum can be used for remote sensing purposes. This absorption of electro magentic radiation may cause emission of energy from the substance itself in the form of radiations. The radiation may be emitted as a function of its structure and temperature at longer sensing wavelength.

The incident radiation may be transmitted, that is, passed through the substance. The wavelength range with high atmosphere transmittance are termed as atmospheric windows and used to acquire remote sensing images.

A portion of the incident radiation is reflected back to the atmosphere from the surface of a material. This phenomenon takes place from the surfaces, that are smooth relative to the wave length of incident energy.

1.2 Spectral Reflectance Characteristics

Various earth surface features can be identified, mapped and studied on the basis of their spectral characteristics. To utilize remote sensing data effectively the spectral characteristics of the particular feature under investigation is useful. The reflectance characteristics of features on the earth's surface can be quantified by measuring the proportion of energy reflected by the feature at different wavelengths. The ability to spectrally define a feature or surface is defined as spectral signature or spectral reflectance curve of the feature. Spectral reflectance curves represent percent of incident light reflected by the material as a function of wavelength. These curves, drawn from the reflectance values of each feature may be used to select the wavelength region(s) in which remote sensing data are acquired for a particular application.

1.3 Radiometric Measuring Systems

For the interpretation of multispectral remotely sensed data, it is desireable to collect 'in situ' reflectance data in the same spectral band. The spectral reflectance data may be collected through ground based measurements of reflectance of features using multispectral 'in situ' radiometric measuring systems such as radio meter, spectroradiometer etc.

These measuring systems are non imaging instruments that measure electromagentic radiation using optical techniques. These instruments do not produce a picture, but integrate overtime, space, and wavelength to produce a spectral curve. They also produce a set of numbers, or a single number that characterizes the electromagentic power that is emitted from, reflected by, and/or transmitted through a surface or region of space.

Figure 1. shows a general system comprised of three major elements whereon radiant energy reflected or emitted from the target is sensed.

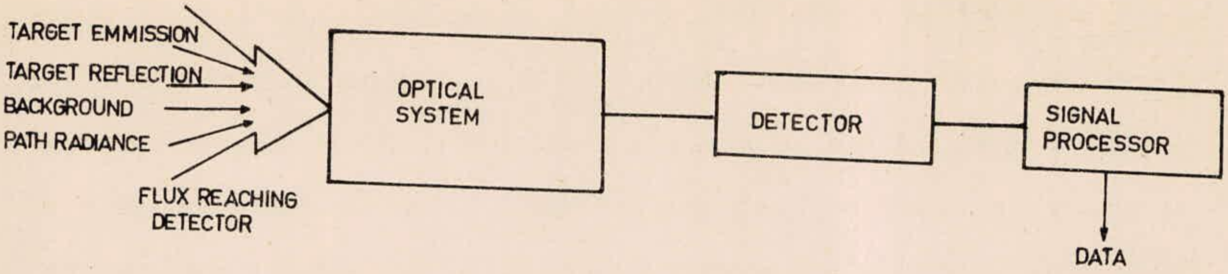


Fig. 1

These elements are: the optical system consisting of lenses, mirrors, apertures, modulators, and dispersion devices; the detector providing are electrical signal proportional to the irradiance on its active surface; and the signal processor performing specified functions on the electrical signal to provide the desired output data.

1.3.1 Radiometers

Radiometers are available with a wide variety of features for diverse applications. The broad band infrared radiometer consists of a detector with wide band having flat spectral response over the infrared region for measurement of the total radiance from a target.

In case of visible near infrared wavelength spectrum broad band radiometers are applied in the measurement of radiant fluxes originating from solar insolation. Radiometers employ one of three detector types; photomultipliers, photocells, or silicon photodiodes with a matching optical filter to achieve the desired spectral responsivity.

A multiband radiometer that is suited for a variety of applications where speed of operation is not a factor, uses a single optical and electronic signal processing system with several optical filters that may be manually positioned to select a desired spectral band. Multiband radiometers are also made by combining several single band radiometers into a compact package. Each radiometer has a seperate signal processing system and the individual radiometer outputs are available simultenously in analog or digital form. The advantages of these instruments is their ability to quickly measure optical quantities and properties from desired portions of the optical spectrum without mechanical and/or electronic adjustment.

1.3.2 Spectro radiometers

Spectroradiometers measure flux in much narrower band. In this in place of filter, dispersion device is used that seperates optical radiation into its spectral components which are directed to a detector. On the basis of dispersion of the radiations into spectral components, there are three basic types of spectradiometers,

(i) The filter wheel radiometer,

(ii) The prism or grating spectroradiometer and

(iii) The interferometer.

In case of filter wheel radiometer a number of filters, arranged in a circle, are rotated one by one into the position of the single filter. In this approach a large number of spectral bands can be precisely specified. The main disadvantage is the time required for data acquisition for a spectral scan.

The dispersion element of prism spectro radiometer consists of a prism whereas in a grating spectroradiometer reflection grating is employed for the purpose. The spatial dispersion of the prism instrument is less than that of the grating instrument, and it is therefore mechanically more complicated to arrange the detectors in the prism instrument. The grating instrument tends to be more delicate and is usually not capable of as rapid a spectral scan as the prism instrument, since the mechanism used to mount the grating must be more rugged and simpler.

Fourier Transform spectroradiometers applies variations of the Michelson interferometer to produce an interferogram by rapid back and forth translation of the adjustable mirror. The changing intensity of the central fringe of the inter ference pattern is sensed by a detector. The output signal from the detector is usually averaged over many of the mirror, translations to produce the interferogram. Advantages of the fourier transform spectroradiometer are high sensitivity and spectral resolution. These type of spectroradiometer are delicate and require great care in their calibration and use in the field.

2.0 REVIEW OF LITERATURE

The effective utilization of remotely sensed data requires thorough knowledge and understanding of the spectral characteristics of the various earth surface features and the factors that influence these spectral characteristics. A knowledge of the spectral characteristics of the various vegetation, soil, water, and other earth surface features of interest is a basic and very essential ingradient for proper analysis and interpretation of remote sensor data.

The spectral characteristics of various earth surface features do not remain static-they change with geographic location and time. Seasonal changes or temporal variability of the biological system also effects the spectral characteristics of a particular feature. In addition to the spectral and related temporal consideration, the spatial characteristics of the biological system must be taken into account. So it is vitally important to take into consideration the spatial and temporal variations, which affect the spectral characteristics.

Several investigaters have attempted to study dynamic behaviours of reflectance characteristics of various earth features. On the basis of these studies characteristics of some of the most important features namely, vegetation, soil and water are briefly discussed.

2.1 Vegetation

The spectral reflectance of green vegetation is distinctive and quite variable with wavelength. Fig.2 shows a typical spectral reflectance curve for green vegetation. In the visible wavelengths, pigmentation dominates the spectral response of plants, specially chlorophyll. The chlorophyll of green leaves usually absorbs 70 to 90 percent of the light in the blue (about 0.45 μm) or red part (about 0.675 μm) of the spectrum (Klenshrin and Shulgin, 1959). Leaf pigments affect light absorptance and hence reflectance of plant leaves. Coblentz (1913) and Shull (1929) showed a depression in the reflective curve at 0.68 μm which is attributed to absorption of light energy due to the presence of chlorophyll. Hoffer and Johansen (1963) illustrated marked differences in spectral response due to different leaf pigments in coleus leaves. The effects of differences in pigmentation on leaf spectra are seen in Fig. 3.

In near-infrared protion of the spectrum, there is a marked increase in reflectance in passing from the visible to the near infrared at approx. 0.7 μm. In comparison to visible wavelength, in this region healthy green vegetation is characterised by very high reflectance, very high transmittance, and very low absorptance. In this region internal structure of plant is the main fac tor which controls the reflectance. In comparison to the reflectance from a single leaf, multiple-leaf layers can cause an even higher reflectance (upto 85%) in the near infrared protion. This is due to the fact that energy transmitted through the first (upper) layer of leaves and reflected from a second layer is partially transmitted back through the first layer (Fig.4). In the middle-infrared portion of the spectrum the spectral response

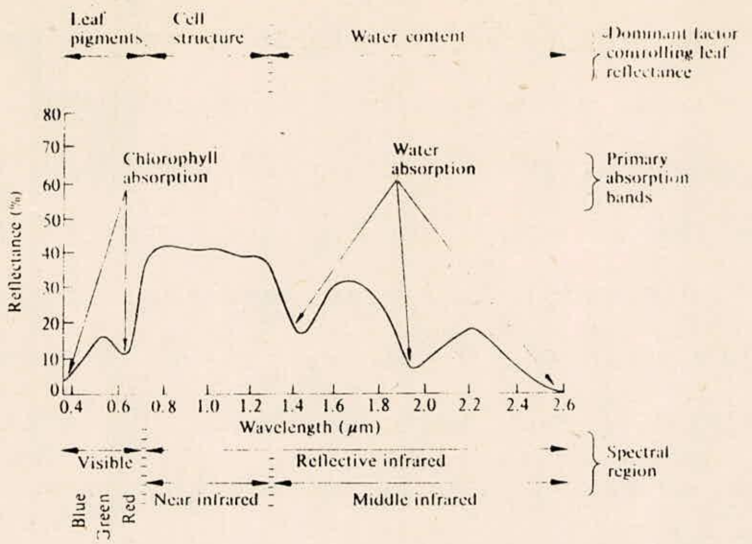


Fig.2 : Significant Spectral Response Characteristics of Green Vegetation

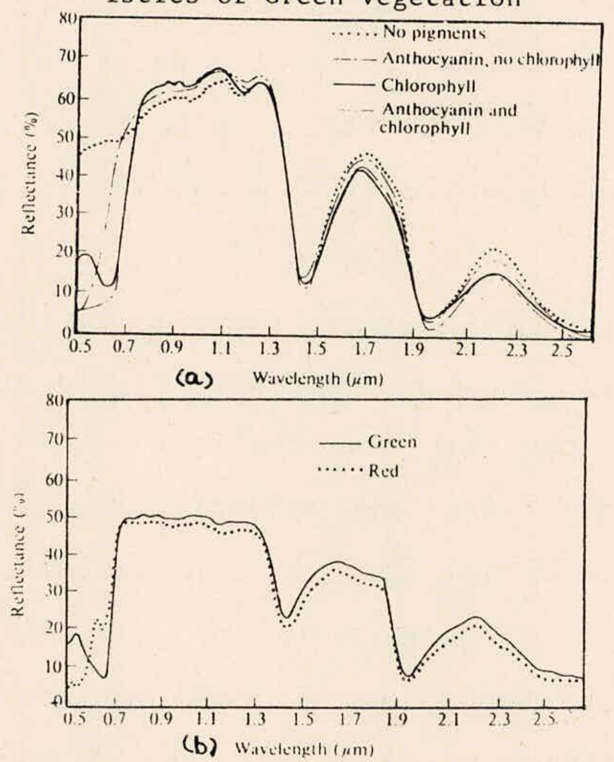


Fig.3 : The Effect of Pigmentation on Leaf Reflectance (a) Coleus leaf (b) Maple leaf

of green vegetation is dominated by strong water absorption bands which occur near 1.4,1.9 and 2.7 μm. Hoffer and Johansen (1969) showed the close relationship between water absorption and reflectance of a healthy green leaf (Fig. 5). In wavelengths where water absorption is high leaf reflectance is low. As the moisture content of leaves decreases, reflectance in this middle infrared wavelength regions increases, appreciably. In Fig.6 spectral curves for corn leaves are shown with different water contents. The decrease in moisture content does not cause significant spectral differences until the moisture content of the plant has become very low. The variations in spectral reflectance of vegetation result from growth stages. In agriculture crops these can be caused by differences in variety, planting date, soil types or soil moisture conditions. Spectral reflectance of rice fields at different growth stages is shown in Fig.7.

2.2 Soils

The soil curve shows considerably less variations in reflectance. The soil is a complex mixture or materials having various physical and chemical properties which can affect the absorptance and reflectance characteristics of the soil. Some of the factors that influence the spectral reflectance of soils are moisture content, soil texture, soil colour, the amount of organic matter and iron oxide content, and surface roughness characteristics.

The presence of moisture in soil decreases its reflectance in all the wavelength regions. Soil moisture content is strongly related tc the soil texture, coarse, sandy soils

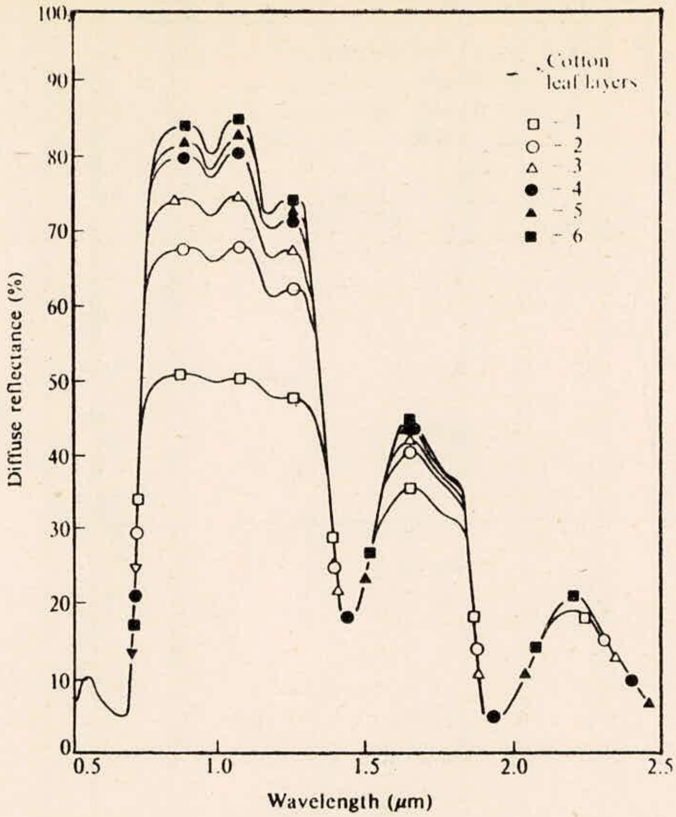


Fig.4: Reflectance From Combinations of Cotten Leaves

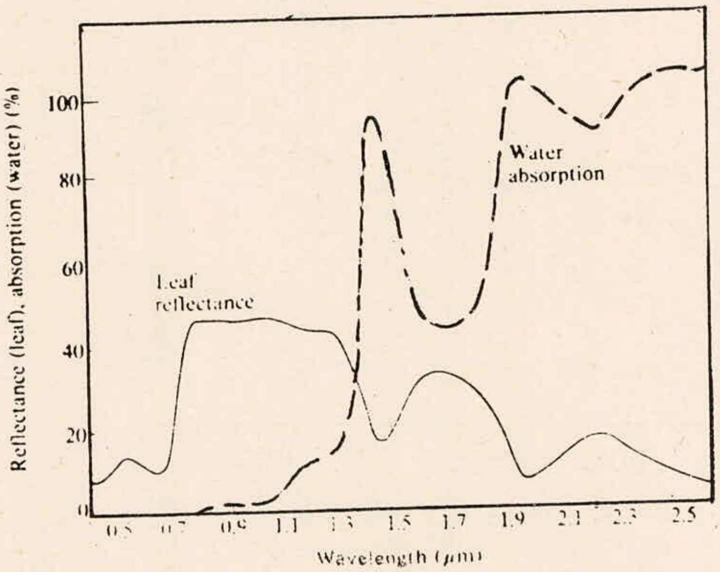


Fig.5: The Inverse Relationship Between Leaf Reflectance and Water Absorption

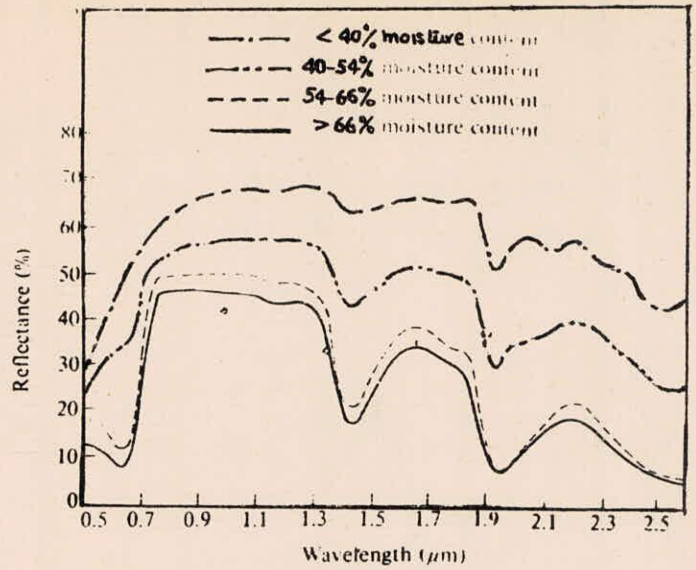


Fig.6: Effect of Moisture Content on Reflectance of Corn Leaves.

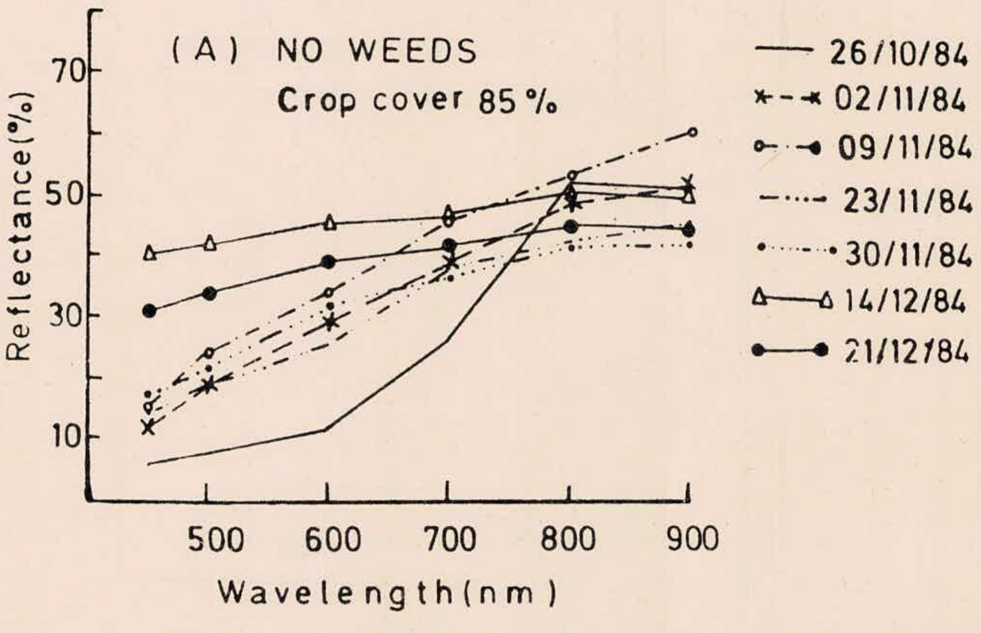


Fig.7: Spectral Response of Rice Crop at various Growth Stages.

are usually well drained resulting in low moisture content and relatively high reflectance. Fig.8 shows typical reflectance curves for a sandy soil at three different levels of moisture content. Soil texture, which refers to the relative proportions of clay, silt and sand particles present in a soil mass, has an influence on spectral response. In the absence of water, coarse texture soils appear darker than fine textured soil. Fig. 9 shows reflectance curves for soils of various texture.

It has been found that particle size of soil also effects the reflectance, as particle size decreases, the soil surface becomes smoother and so reflectance increases. Orlov (1966) showed the dependence of the reflection coefficient (R) on aggregate dia (d) by an exponential equation:

$$R = K. 10^{-nd} + R^{\infty}$$

where K, n are constants describing the shape of the curve and R^{∞} is the reflection coefficient of aggregates of max. dia. Obukhov and Orlov (1964) found that all soil had spectral Characteristics related to soil colour. Minimum reflection occured in the blue-violet portion while maximum was in the red region of the spectrum, organic matter and from compounds significantly influence the reflectance characteristics of a soil. The relationship between organic matter and reflectance is different for different soil types. In general organic matter tends to reduce overall reflectance of soil due to its capacity for radiant energy absorption. An increase in iron oxide can cause a significant decrease in reflectance throughout the 0.5 to 1.1μm wavelength region, but not too much affected about 1.1μm (Figure 10).

Structure roughness due to tillage treatment has a substantial influence on reflectance of soil which tend to aggregate. The effect of tillage operation on soil reflectance in shown in Fig.11 Lower reflectance values observed in all ploughed soil compared to uploughed (bare) soils may be due to shallow effect which is caused by rough surface of ploughed soils.

2.3 Water

As with vegetation and soil, the spectral response of water varies with wavelength, according to the energy-matter interactions taking place.

Water bodies absorb nearly all incedent energy in both the near-infrared and middle infrared wavelengths, even when the water is very shallow. Therefore, since water obsorbs energy in the near and middle infrared wavelengths so effectively, there is very little energy available to be reflected at these wavelengths. Due to this water features have a significant and distinctly lower reflectance. Such distinct differences in infrared reflectance allow under water bodies to be easily identified and mapped. In the visible portion of the spsectrum, the energy-matter interactions for water bodies become more complex and depend upon a number of interrelated factors. The reflectance term can involve reflectance from the surface of water, from the bottom materials, or

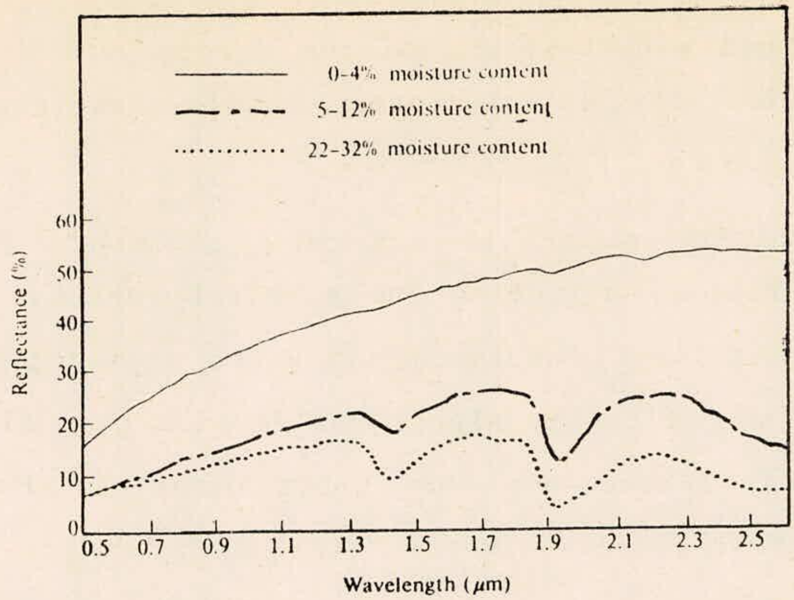


Fig.8: Spectral Reflectance Curves for Sand in three moisture content groupings

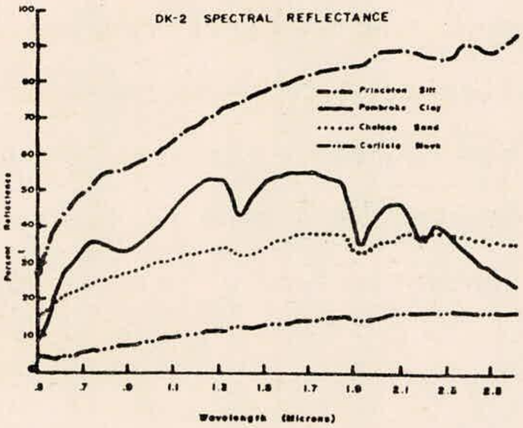
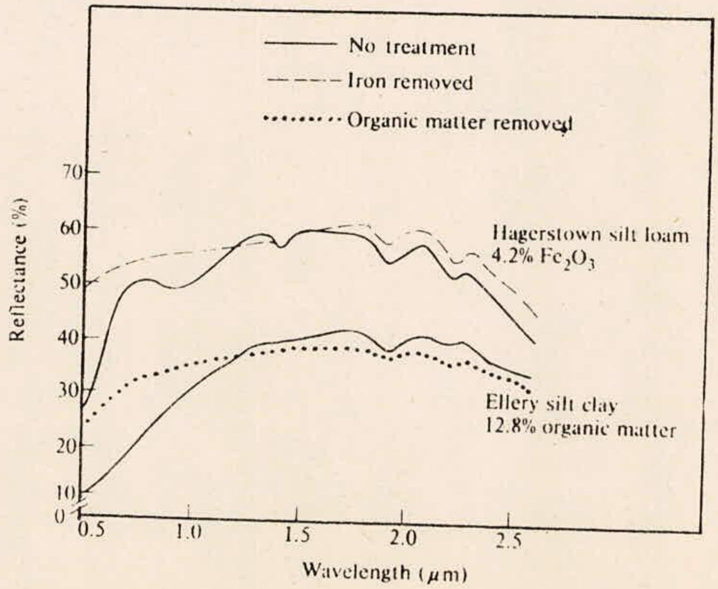


Fig.9: Reflectance curves for soils of various textures.

Fig.10: Spectral reflectance curves showing the effect of removal of iron oxide and organic matter from the soil.



from suspended materials within the waterbody. Clear water obsorbs relatively little energy having wavelengths less than about 0.6 μm (Fig. 12).

Turbidity caused by suspended sediments is one of the major factors affecting the spectral response of water bodies. Bartolucci, Robinson and Silvo showed that turbid water as a significantly higher reflectance than clear water and the peak reflectance for turbid water is at a longer wavelength than for clear water. (Fig.13).

The concentration of chlorophyll in water also affects the spectral response. Increase in chlorophyll concentration tend to decrease water also affects the spectral response. Increase in chlorophyll concentration tend to decrease water reflectance in blue wavelengths and increase in the green wavelength (Fig.14). These changes have been used to monitor the presence and estimate the concentration of algae via remote sensing data.

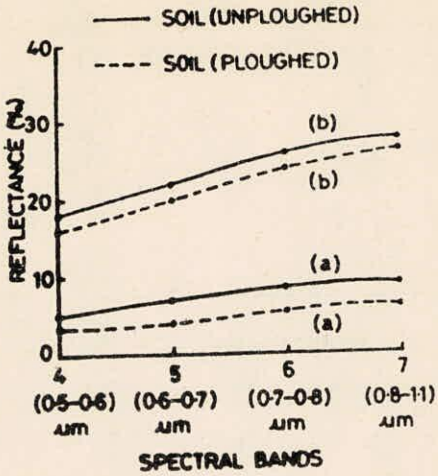


Fig.11: Effect of tillage operation on spectral reflectance of soil

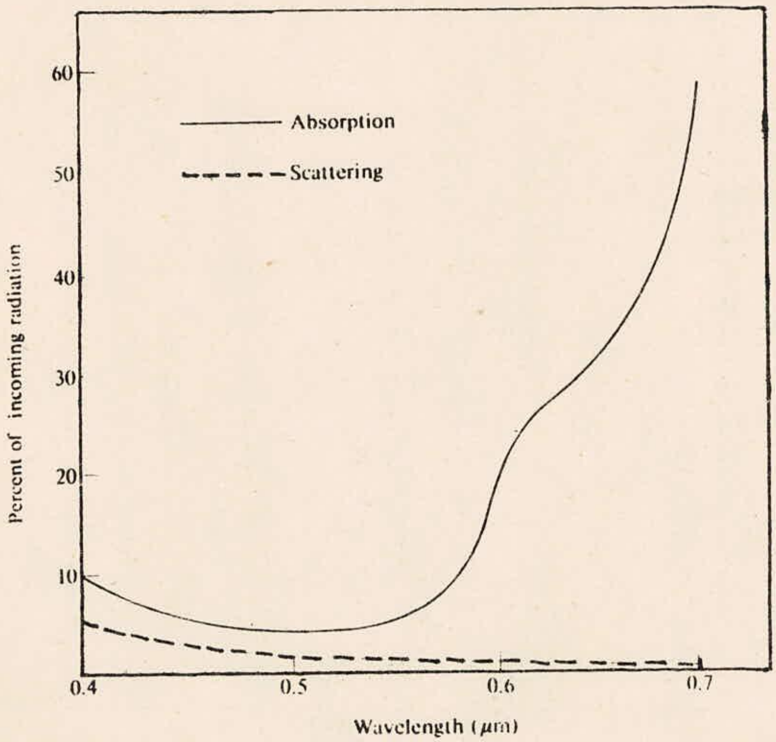


Fig.12: Absorption and scattering characteristics of distilled water

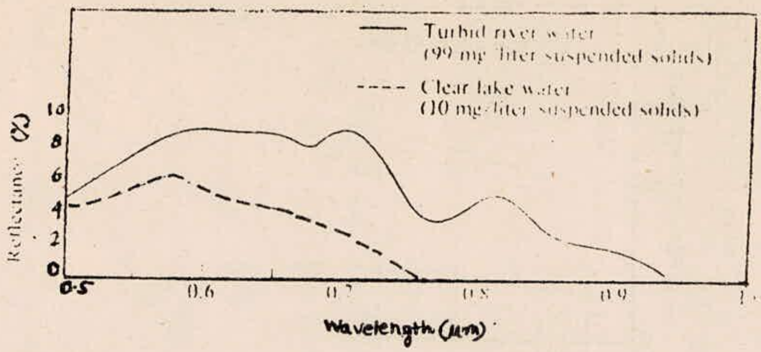


Fig.13: Spectral reflectance characteristics of turbid and clear water.

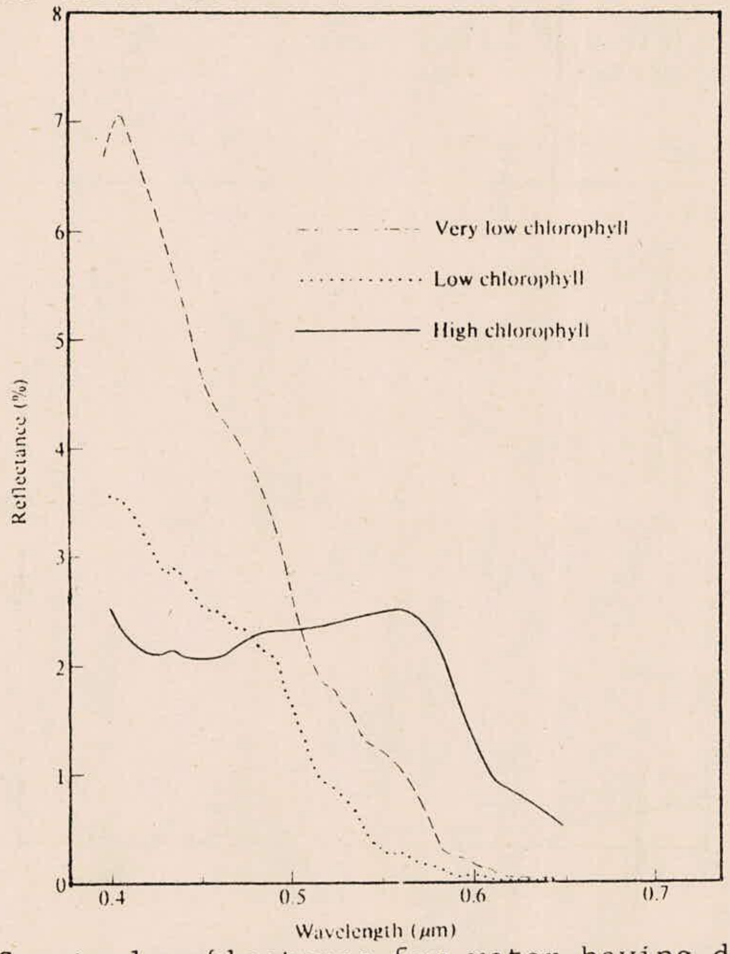


Fig.14: Spectral reflectance for water having different concentrations of chlorophyll

3.0 STATEMENT OF THE PROBLEM

Effective interpretation of multispectral remote sensor data is dependent upon knowledge of the spectral characteristics of earth surface features. In processing multispectral data by computer, the machine simply utilizes the measurement that are obtained in the different wavelength bands without understanding why differences in spectral response value exist. So, for effectivety utilization of computer aided analysis techniques to analyse multispectral data, proper interpretation of the spectral characteristics of the data is essential, the spectral characteristics curves of various earth features can be developed by measuring spectral reflectance as a function of spectral range.

This study has been under taken to generate spectral reflectance curves and to study their characteristics for various types of cover features occuring in Roorkee and surrounding areas including Doon valley.

4.0 METHODOLOGY

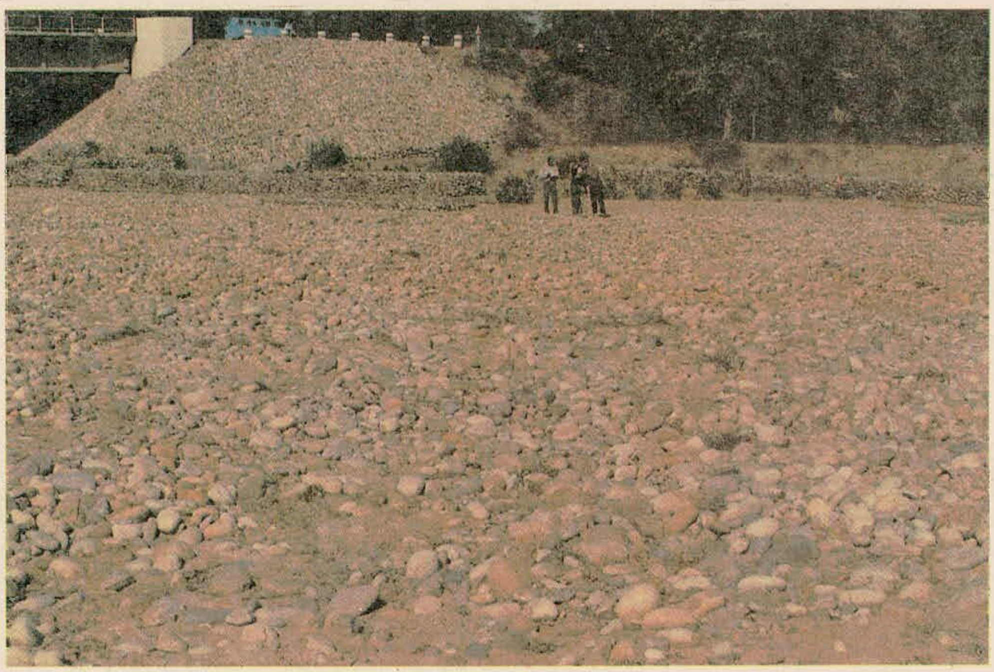
Reflectance is dimensionless ratio of radiant energy reflected from object to that incident upon it and expressed as a percentage.

$$\text{Reflectance} = \frac{\text{Energy reflected from the object}}{\text{Energy incident upon the object}} \times 100$$

Studies of 'insitu' spectral reflectance measurements show the nature of interaction between electromagentic radiations (EMR) and different features. In this study a grating type spectroradiometer was used for collection of spectral reflectance values of various features. The features taken for the study includes-green grass, dry grass, concrete surface, road surface (Bituminous), mixed gravel, sand surface, bare soil and water. The spectral reflectance data of various features were collected in the surroundings of Roorkee area including Doon Valley. (Plate 1 and 2).

The instrument measures as a function of wavelength the energy coming from an object with in its field of view. It has five gain ranges to make it verstile to measure radiance right from low reflectance surfaces. This instrument is capable of a resolution of 2% on reflectance. The instrument gives the relative spectral reflectance of the object under study. Technical specifications of the instrument are given below:

Optics	: f/3 Newtonian telescope
Field of view	: 10 deg. C.
Spectral range	: 0.45 - 1.01 microns
Operating temp. range	: $5^{0}C$ to $50^{o}C$



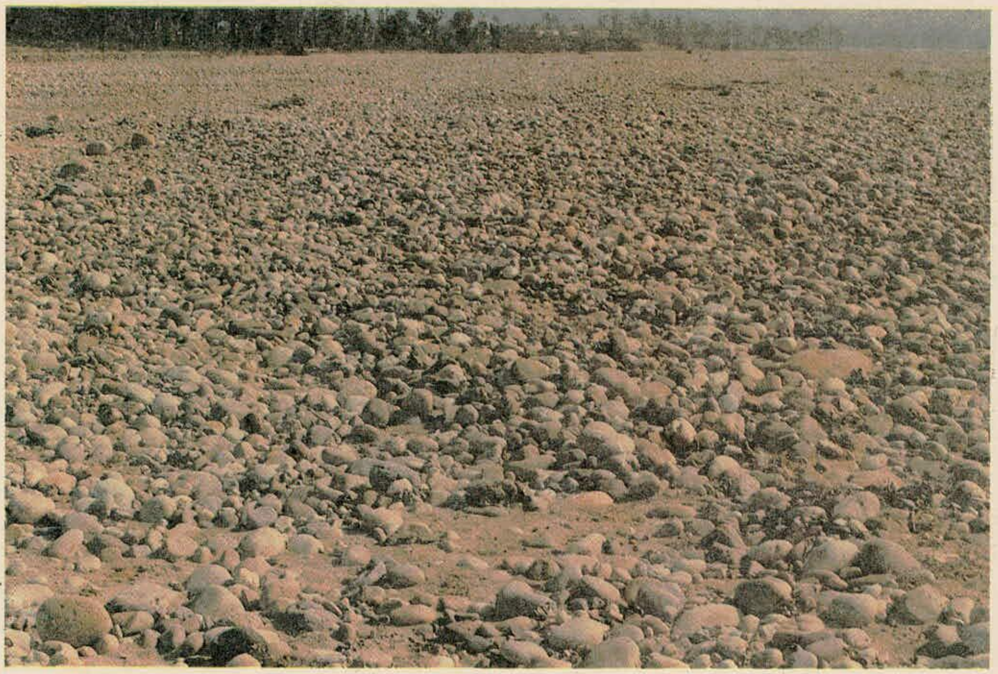
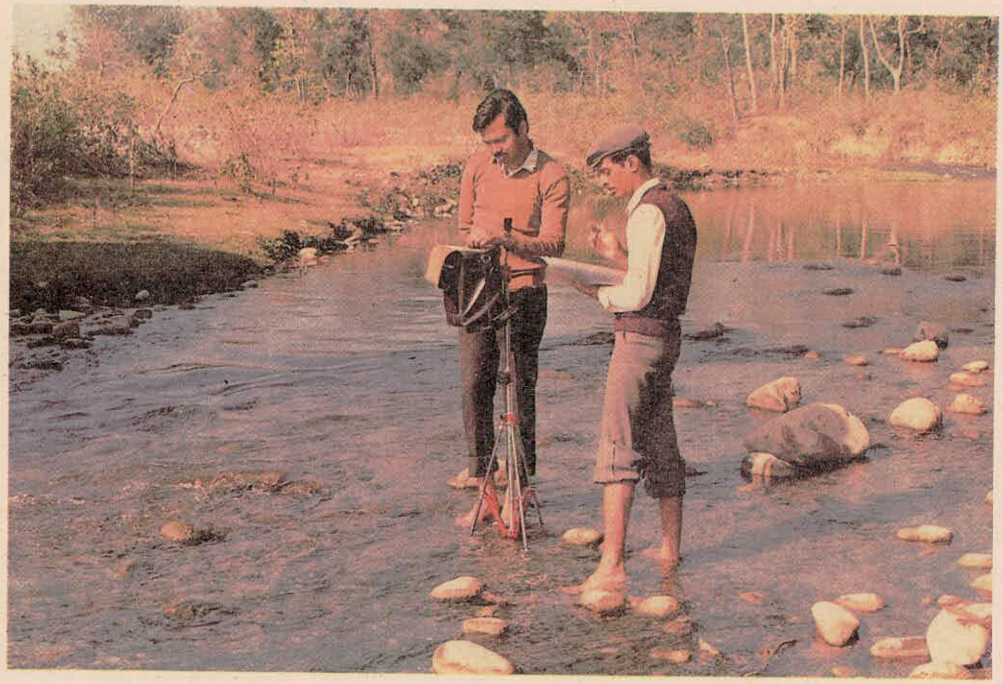


Plate 1: Mixed gravel area near Dehradun



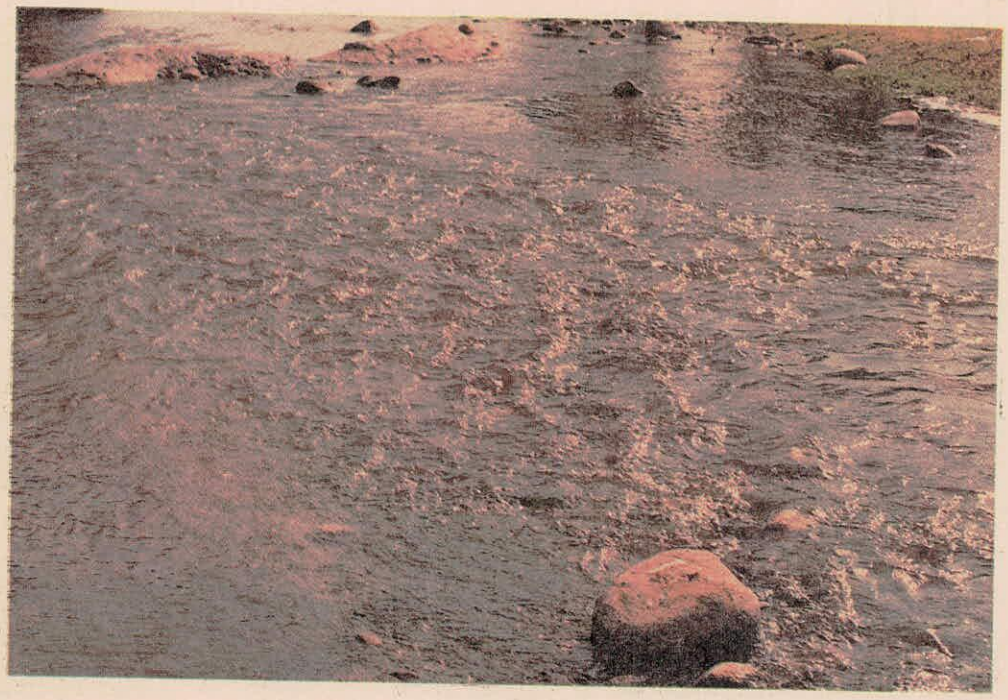


Plate 2 : Water streams near Dehradun

A barium sulphate (Ba S04) coated plate is used as standard reference. The readings are taken for both Ba S04 plate and the object under study in the spectral range from 0.4 μm to 1.02 μm with an interval of 0.02 μm. While taking the meter reading gain values are also noted down. The meter readings are devided by corrèsponding gain values to convert meter readings into normalized values. The gain values are so chosen that the panel mater readings lie between 1.0 and 4.0 .

The spectral reflectance is calculated as

$$R = \frac{\text{normalized meter readings for object}}{\text{normalised meter reading Ba S04 plate}}$$

A curve is plotted by taking wavelength as abscissa and reflectance as ordinate. The reflectance curves drawn for various features with temporal variations are presented in figure 15. while values of spectral reflectance are presented in Table 1.

TABLE-1

MEAN VALUES OF SPECTRAL REFLECTANCE (%)

WAVE LENGTH	GREEN GRASS	DRY GRASS	ROAD SURFACE	CONCRETE SURFACE
0.40	39.16	38.92	6.76	46.91
0.42	40.93	39.80	8.80	45.67
0.44	40.99	41.22	9.73	46.21
0.46	40.93	40.60	9.68	47.26
0.48	44.35	41.64	6.84	49.34
0.50	43.15	41.54	9.66	47.79
0.52	36.24	37.86	9.66	46.94
0.54	39.17	31.43	8.33	43.78
0.56	22.12	27.95	8.29	42.17
0.58	18.22	23.15	7.68	38.53
0.60	12.82	19.33	7.94	36.69
0.62	10.41	16.80	7.87	33.97
0.64	9.32	14.66	7.79	35.15
0.66	8.80	13.11	8.23	34.65
0.68	9.65	14.27	8.43	34.67
0.70	9.15	14.31	8.67	34.90
0.72	9.52	15.07	8.88	36.08
0.74	9.35	15.51	9.05	37.40
0.76	10.26	16.28	9.58	39.57
0.78	10.85	17.11	10.03	41.32
0.80	12.00	18.20	10.15	43.32
0.82	14.11	19.97	10.37	43.87
0.84	16.16	21.50	10.89	43.52
0.86	19.71	24.00	11.43	44.16
0.88	23.16	25.84	11.73	45.34
0.90	27.46	27.46	12.13	44.69
0.92	32.86	29.77	12.43	44.79
0.94	37.12	31.62	12.56	44.90
0.96	38.23	32.67	12.89	44.18
0.98	38.50	32.67	12.99	43.91
1.00	39.14	32.98	13.15	43.68
1.02	38.53	32.45	13.26	44.04

TABLE-1 (contd.)

WAVELENTH	BARE SOIL	SAND SURFACE	MIXED GRAVEL	WATER
0.40	44.19	39.49	52.94	27.36
0.42	40.94	36.05	49.16	21.97
0.44	41.00	36.79	47.88	20.72
0.46	41.61	37.76	50.02	20.72
0.48	40.51	36.59	47.16	20.72
0.50	38.67	37.51	44.88	21.64
0.52	40.31	36.80	45.77	22.38
0.54	36.19	34.06	46.89	21.92
0.56	32.17	30.74	44.33	20.71
0.58	27.36	30.34	40.63	16.67
0.60	23.92	27.62	36.94	14.51
0.62	22.69	26.54	20.97	11.67
0.64	21.71	25.42	28.33	10.37
0.66	20.78	24.89	28.46	7.91
0.68	20.63	24.09	28.18	8.57
0.70	21.54	24.26	28.66	8.98
0.72	22.38	25.33	28.04	8.19
0.74	22.84	26.29	27.06	9.11
0.76	24.86	26.81	26.59	9.69
0.78	26.16	27.47	27.67	8.92
0.80	28.58	28.36	28.36	10.11
0.82	30.18	21.76	29.28	10.47
0.84	31.77	29.48	31.63	11.47
0.86	32.19	29.89	32.80	10.11
0.88	33.56	23.67	32.73	9.53
0.90	34.44	30.79	32.46	9.81
0.92	35.48	24.49	21.69	8.98
0.94	34.33	30.81	31.61	8.49
0.96	35.08	31.72	30.49	7.95
0.98	35.71	31.23	32.50	8.09
1.00	35.85	31.26	33.99	7.47
1.02	35.75	31.48	34.52	8.47

5.0 ANALYSIS OF RESULTS

The spectral reflectance values corresponding to Landsat MSS bands were computed by integrating spectral reflectance curves within the respective ranges i.e. (0.5-0.6 μm, 0.6-0.07 μm, 0.7-0.8 μm and 0.8-1.02 μm) wavelengths (Table 2). The curves for reflectance corresponding to four bands are shown in Fig. 16.

The spectral reflectance value have been used to determine various ratioed values. In rationing the reflectance value of an object in one band is divided by the reflectance value of the same object in the another band. In remote sensing the ratio has a great utility in analysing the spectral aspect of features. A total of six ratios 1/2, 1/3, 1/4, 2/3, 2/4 and 3/4 have been calculated to characterise the features as given in the table 3. These are graphically represented in Figure 17 corrosponding to different ratios.

Spectral reflectance curves together with ratioed values for each of the cover types have been studied. Also a comparative study of various cover types have been done to provide better understanding of spectral response which will ultimately help in selecting most appropriate bands and combination of bands or ratios for discrimination among various cover types.

Fig. 18 shows the spectral reflectance curves for green grass and dry grass. From wavelength 0.46 μm to 0.88 μm dry grass reflectance is higher while in wavelength region

TABLE - 2

SPECTRAL REFLACTANCE VALUES CORROSPONDING TO LANDSAT MSS BANDS

BAND FEATURE TYPE ↓	1 (0.5-0.6µm)	2 (0.6-0.7µm)	3 (0.7-0.8µm)	4 (0.8-1.02µm)
1. GREEN GRASS	21.33	7.60	7.83	24.91
2. DRY GRASS	24.08	11.75	12.41	24.42
3. ROAD SURFACE	6.74	6.30	7.27	10.66
4. CONCRETE SURFACE	33.66	27.00	29.92	39.33
5. BARE SOIL	26.64	16.92	18.73	29.13
6. SAND SURFACE	25.75	19.83	20.48	25.54
7. MIXED GRAVEL	34.29	20.92	21.42	27.73
8. WATER	19.65	10.34	9.16	9.25

TABLE 3

BAND RATIOS AND CORRESPONDING VALUES

BAND RATIOS FEATURE TYPE ↓	1\2	1\3	1\4	2\3	2\4	3\4
1. GREEN GRASS	2.8	2.72	0.86	0.97	0.31	0.31
2. DRY GRASS	2.04	1.94	0.99	0.94	0.48	0.51
3. ROAD SURFACE	1.07	0.93	0.63	0.86	0.59	0.68
4. CONCRETE SURFACE	1.24	1.12	0.85	0.90	0.69	0.76
5. BARE SOIL	1.57	1.42	0.92	0.90	0.58	0.64
6. SAND SURFACE	1.29	1.25	1.00	0.96	0.77	0.80
7. MIXED GRAVEL	1.63	1.60	1.23	0.98	0.75	0.77
8. WATER	1.90	2.15	2.12	1.13	1.12	0.99

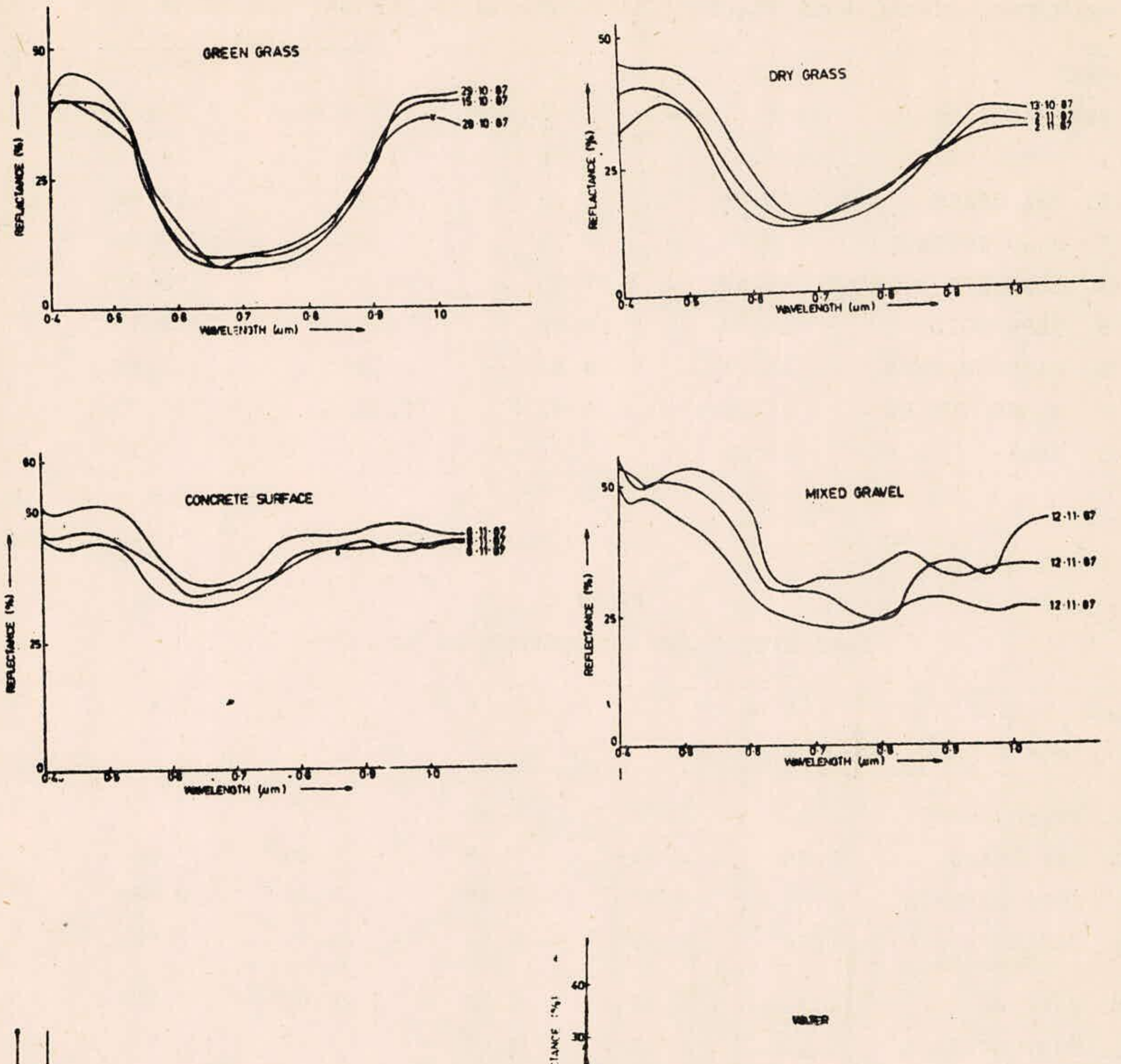
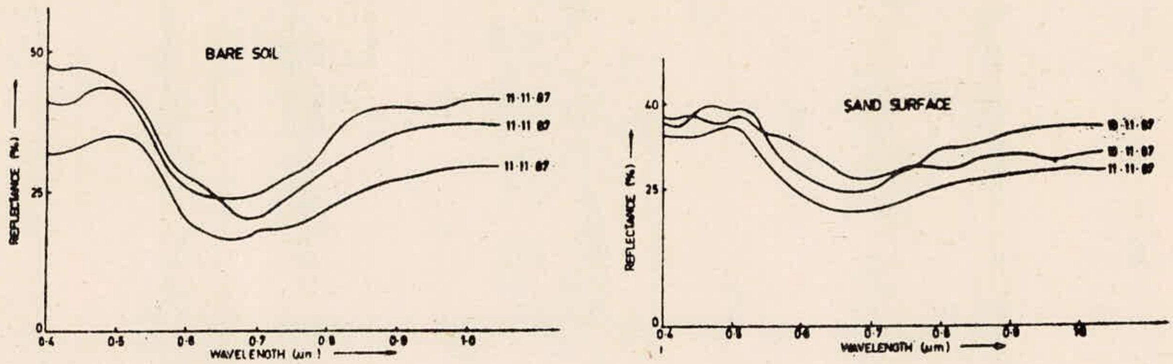


Fig.15 Spectral reflectance curves for various features.

Fig.15 contd..



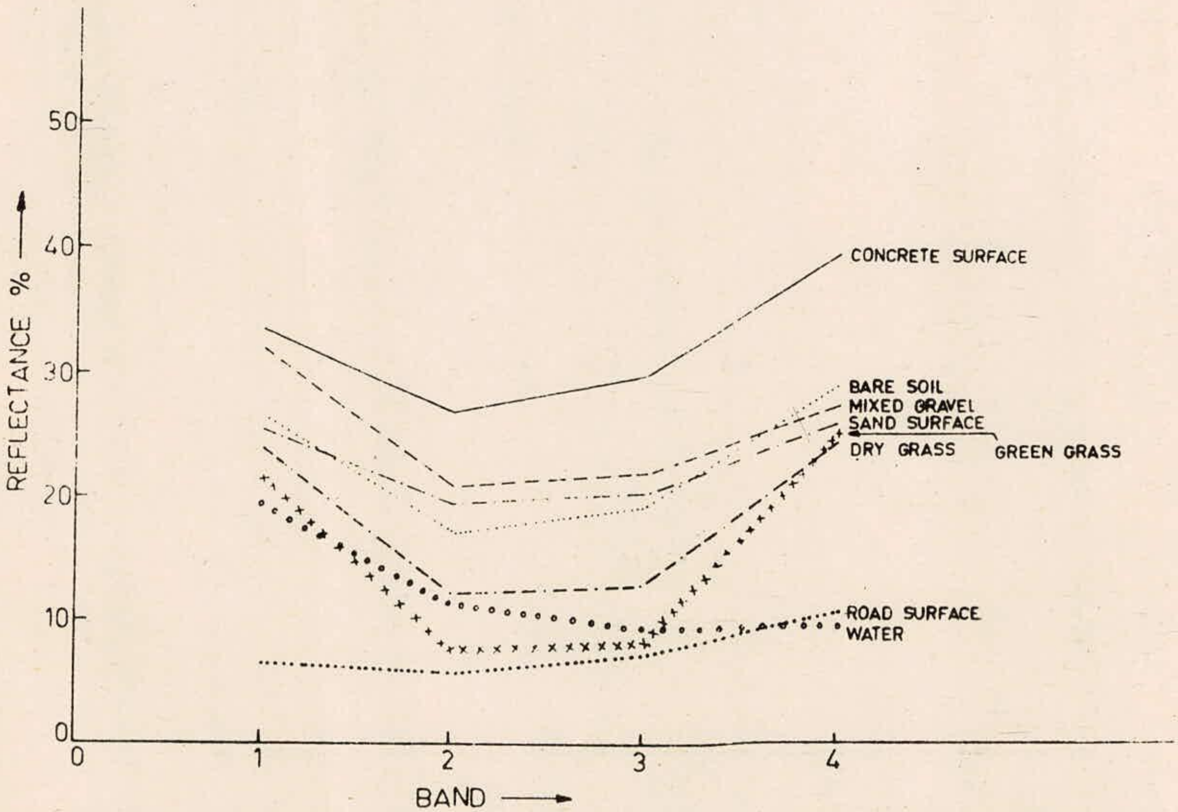


FIG. 16 – SPECTRAL REFLECTANCE CURVES FOR VARIOUS BANDS

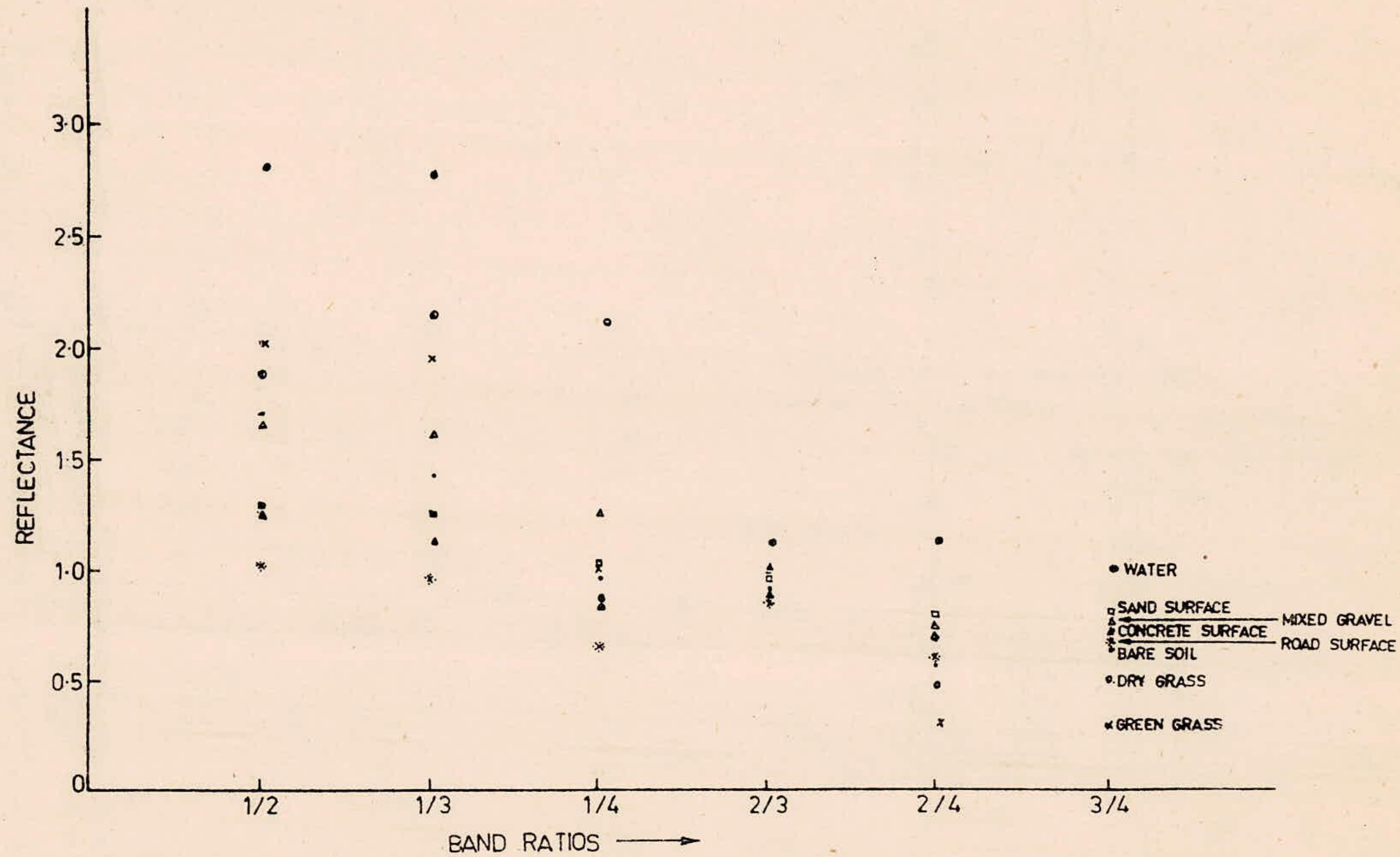


FIG.17 – BAND RATIOS FOR VARIOUS GROUND FEATURES

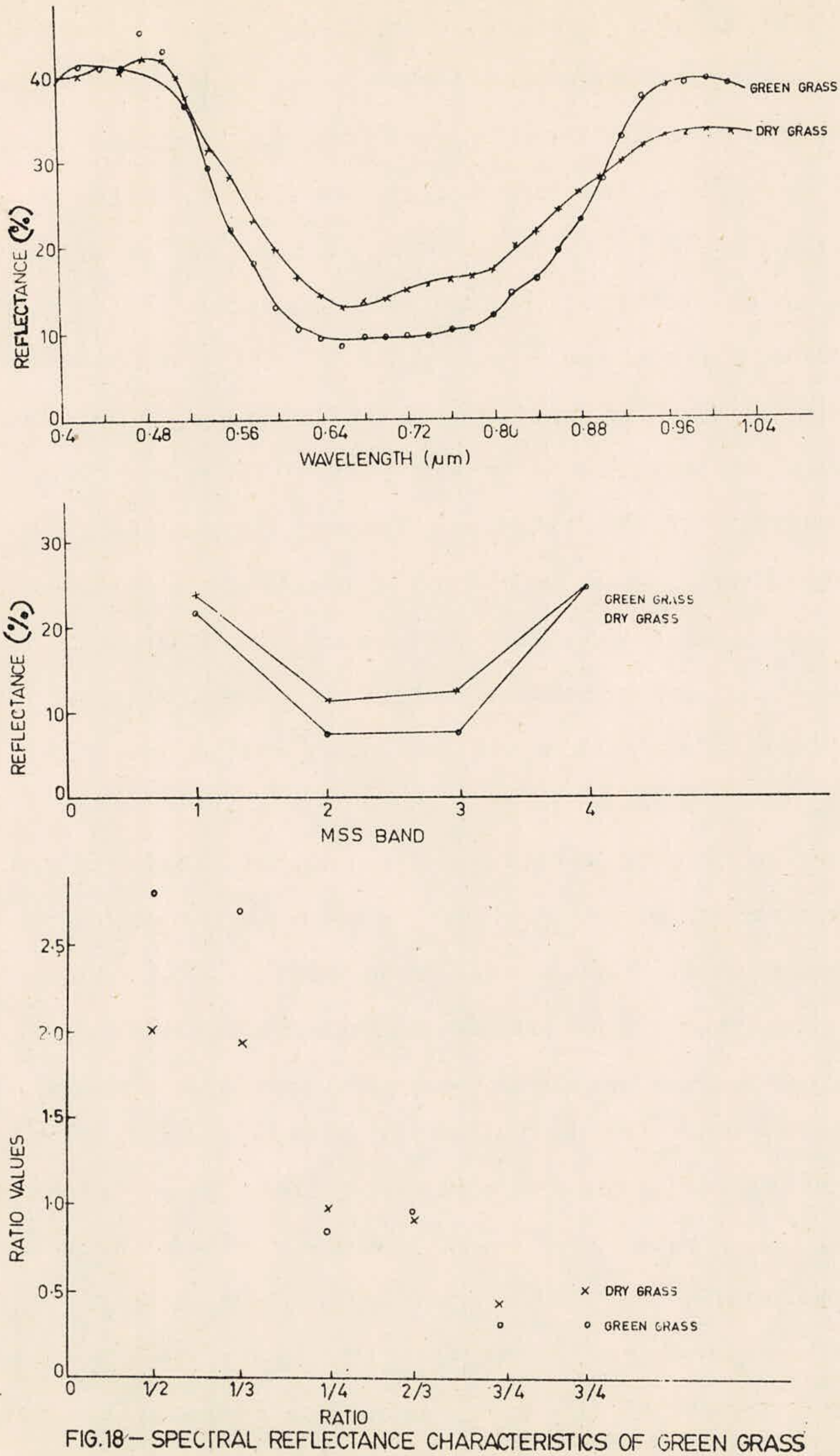


FIG.18 – SPECTRAL REFLECTANCE CHARACTERISTICS OF GREEN GRASS

(0.88-1.02 μm) green grass reflects more. From band 2 to band 3 reflectance pattern of both is almost parallel while in the region between band 1 and 2 and band 3 to 4 the both curves are merging towards each other. Ratioed values at ratios 1/2, 1/3 are quite distinguishable while in ratios 1/4, 2/3, 2/4 & 3/4 are almost similar for both features. Fig.19 shows spectral reflectance characteristics for bare soil, sand surface and mixed gravel. All the three features have almost similar pattern of reflectance. But from 0.4 to 0.76 μm reflectance of mixed gravel is appreciably higher than others. In the later portion the curves are quite close to each other. From band 1 to 2 bare soil and mixed gravel curves are almost parallel while sand curve interact between the two. If one considers ratios 1/2 and 2/3, the features are spectrally separable but for other ratios these are almost similar.

The characteristics of concrete surface and road surface are shown in Fig.20. The reflectance of concrete surface is quite higher than road surface. From band 1 to 2 the characteristics are merging towards each other, while in other bands these are almost parallel to each other. However, ratioed values for both the features are similar. Spectral reflectance characteristics of water and green grass are compared in Fig. 21. From wavelength 0.4 to 0.56 μm the two curves are approaching to each other while from 0.80 to 1.02 μm they are expanding. In wavelength region 0.4 to 0.5 μm and 0.94 to 1.02 μm the two features have a considerable differene. In wavelength region 0.56 to 0.80 μm both features have almost

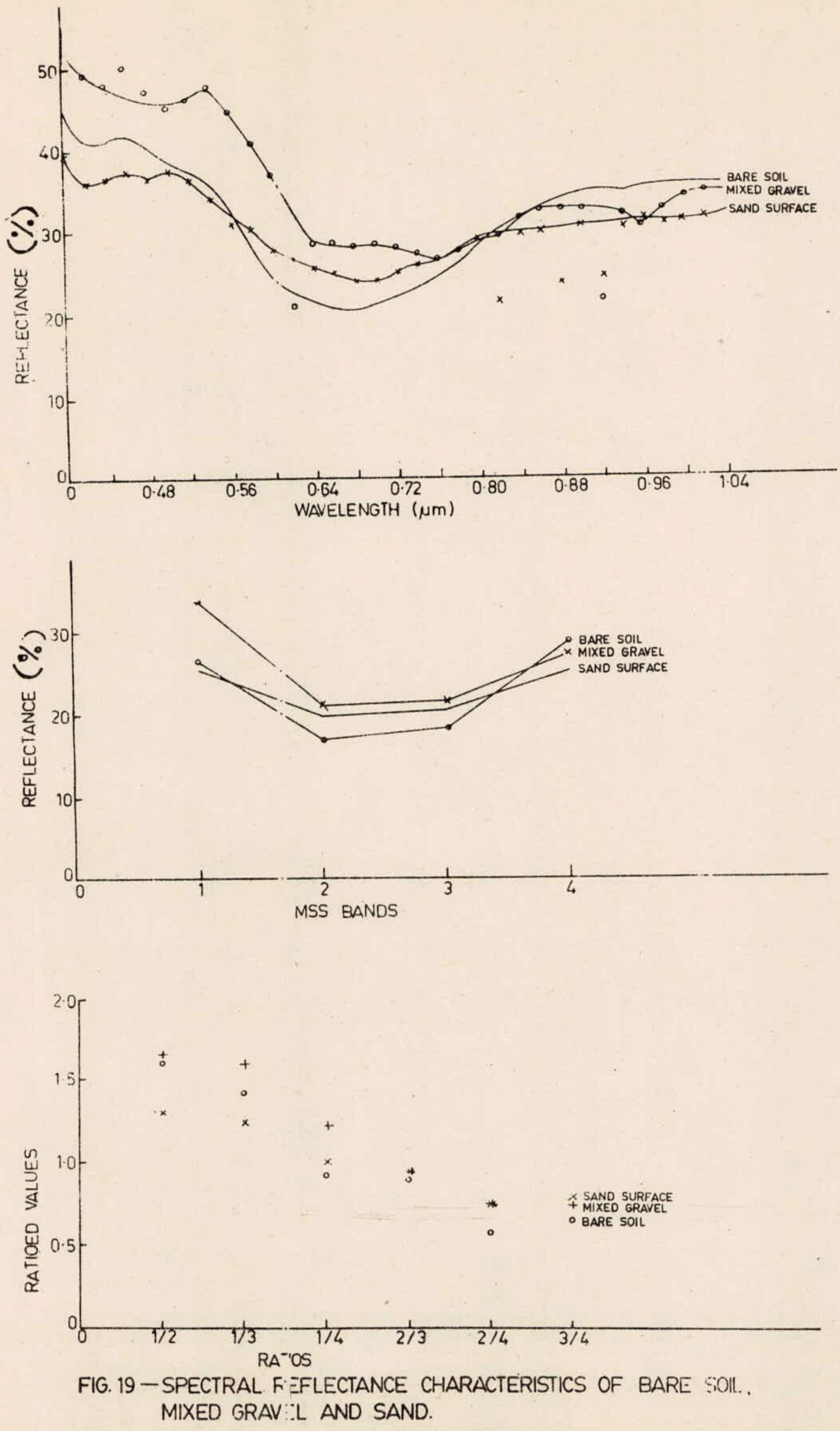


FIG. 19 — SPECTRAL REFLECTANCE CHARACTERISTICS OF BARE SOIL, MIXED GRAVEL AND SAND.

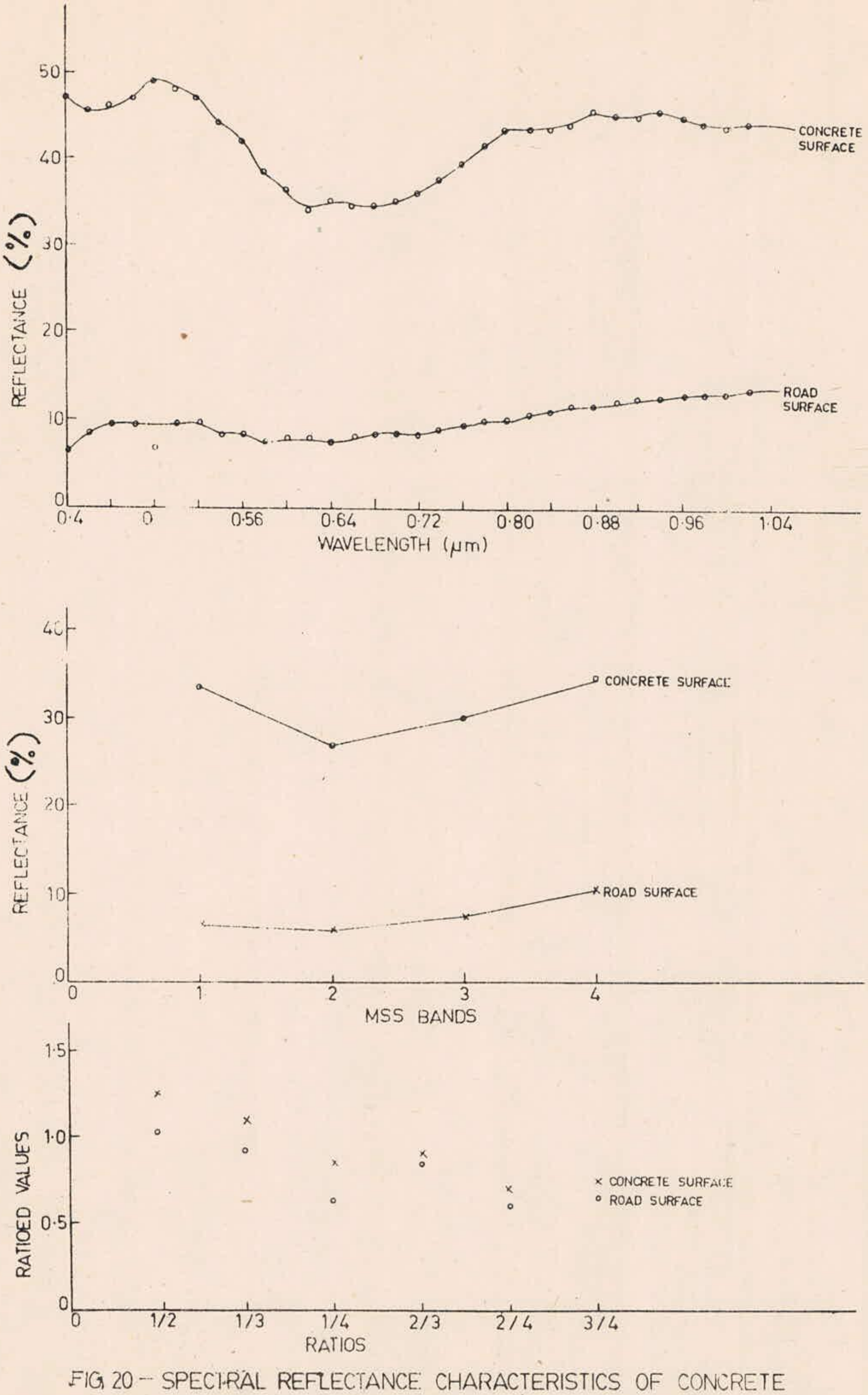
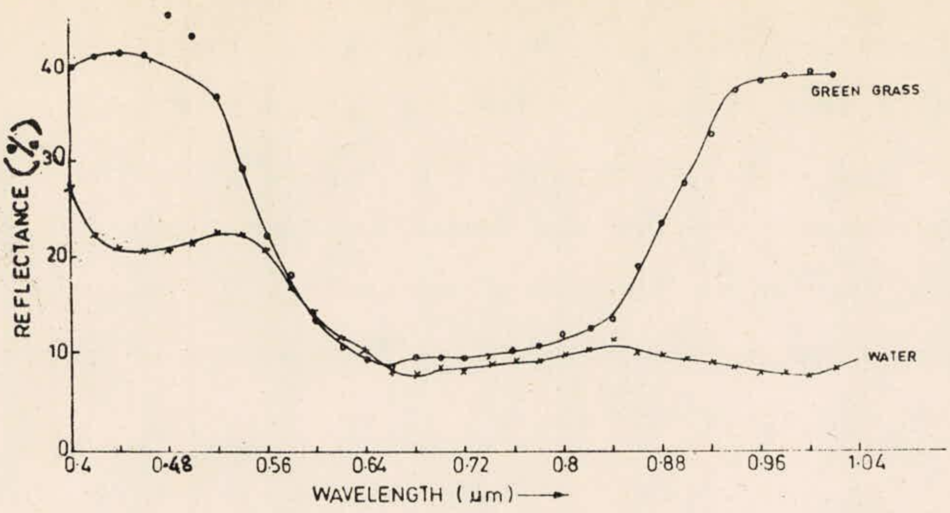
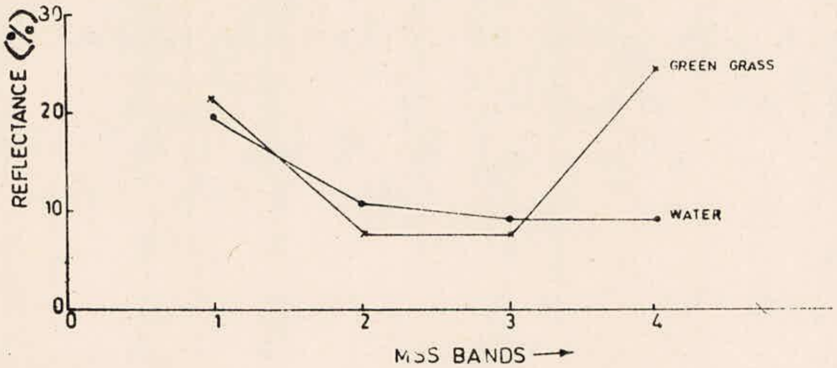


FIG. 20 — SPECTRAL REFLECTANCE CHARACTERISTICS OF CONCRETE AND ROAD SURFACE





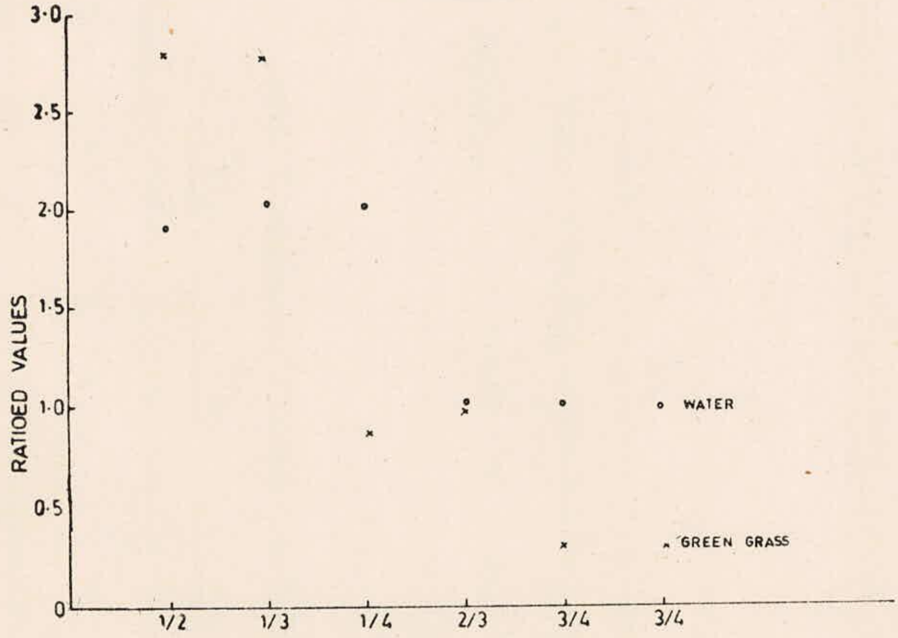


FIG. 21-SPECTRAL REFLECTANCE CHARACTERISTICS OF GREEN GRASS AND WATER

similar characteristics. Except at ratio 2/3, the two features have different values. The reflectance characteristics for sand and water are presented in Fig. 22. In the beginning the two curves are coming closer to each other but beyond 0.56 μm wavelength there are expanding. The ratios 1/2, 1/3, 1/4 have a considerable difference while the ratios 2/3, 2/4, 3/4 are closer to each other.

The reflectance characteristics for bare soil and water are shown in Fig. 23. The characteristics for soil and water are almost similar to characteristics for sand and water as seen from Fig.22.

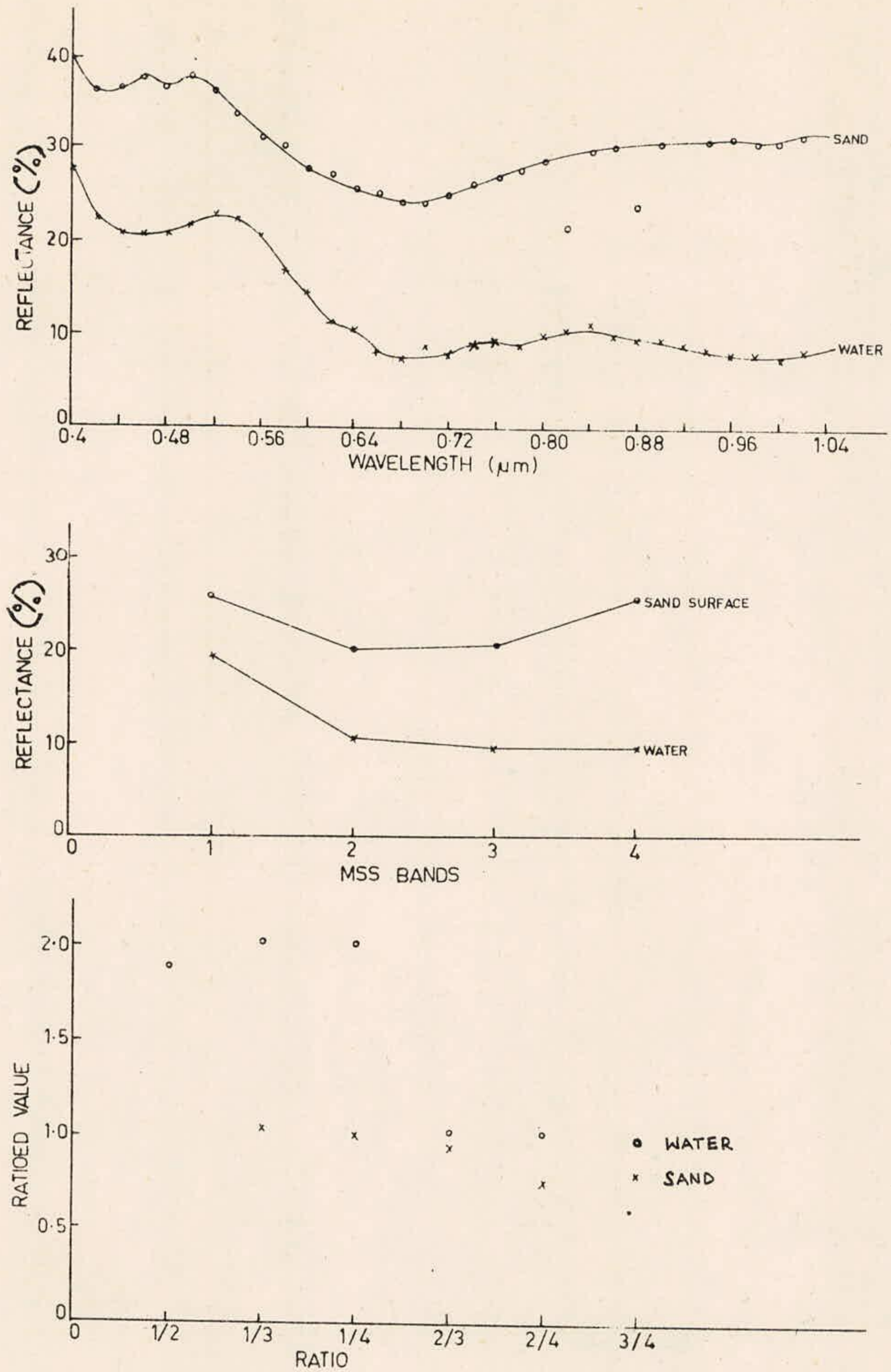


FIG. 22 – SPECTRAL REFLECTANCE CHARACTERISTICS OF SAND AND WATER

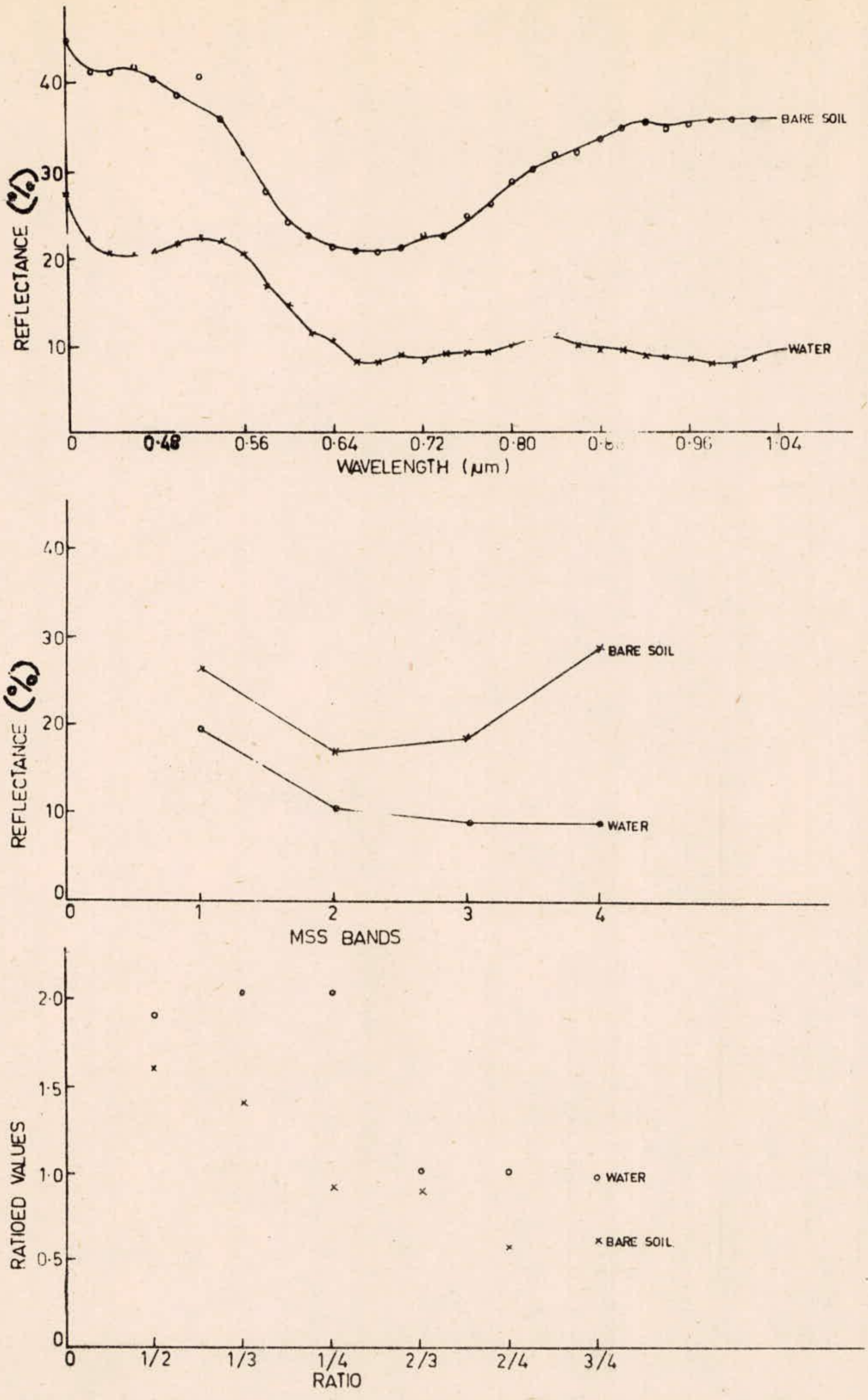


FIG. 23 — SPECTRAL REFLECTANCE CHARACTERISTICS OF BARE SOIL AND WATER

6.0 CONCLUSION

The effective analysis of multispectral scanner data depends on the spectral characteristics of the feature in addition to a knowledge of the computer analysis techniques used. From the study of spectral reflectance characteristics of various features, it is possible to spectrally seperate these features. The features have different reflectance characteristics in different wavelength regions and MSS bands. On the basis of this one can select the most appropriate regions for identification of various earth features and their discrimination among various features.

On the basis of this study it is concluded that in case of green grass and dry grass wavelength region from 0.60 μm to 0.86 μm is good for distinguishing both features. At ratios 1/2 and 1/3 both features can be easily discriminated. The reflectance pattern for bare soil, mixed gravel and sand are almost similar but bare soil has higher value than other two from band 1 to 2. All the three features have nearly equal ratioed values. Although reflectance characteristics of concrete surface and road surface are just similar but reflectance of concrete surface is higher than road surface throughout the spectral range. Both features have almost same values for various combinations of band ratios.

For differentiating green grass from water wavelength regions from 0.40 to 0.52 μm and from 0.88 to 1.02 μm are most appropriate. In both regions green grass have much higher values of reflectance. At ratios 1/2, 1/3, green grass have higher values while at 1/4, 2/4 and 3/4 water have higher values. Bare soil and sand have almost similar pattern as compared with water. Both features have higher reflectance values than water in all the wavelength ranges, while water has higher values in case of ratioed values.

The results of this study have clearly brought out the feasibility of discriminating various earth surface features using spectral reflectance data. These reflectance values could be possibly used for training the supervised classifer to perform digital analysis of CCT data on VAX-11/780 computer system of the Institute. It is proposed that these values may be used for supplying ground truth statistics while performing supervised analysed of CCT data. Considering the fact the CCT data are actually radiance values while spectral reflectance values are percentage reflectance value. It is suggested that band ratio technique may be adopted for classification purpose.

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