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Spectral Response at Different Water Depth Standing in the Field

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Water availability and irrigation management can be estimated in agricultural fields through observation of field water storage. In order to calculate runoff and recharge through these fields, the water depth stored in the haveli fields must meet certain requirements. Remote Sensing data obtain through Satellite in all visible and NIR region might be helpful for such requirements. An experimental study is made to assess the utility of different bands for depicting depth of storage in field. Spectral reflectance was recorded on different depth from 0 to 100 cm of water. Ground Truth Radiometer (GTR) was used to conduct the experiment. Experimental observation shows the variation in reflectance with different depth of water stored in 1 m^3 ponding water. It has been observed that spectral response shows variation under different storage level and different time of observation. To minimize error on observation the readings were taken under uniform sunshine condition and wind velocity. The Radiation under wavelength 0.4 and 1.1 µm was used to collect response in reflectance from experimental fields. The increase in reflectance with was observed with decrease in water level. This could be due to visibility of bottom soil in lower depths. A

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comparison between experimental response data and satellite image data of indicate that there is variation on band 4 and similar trend on band 1, 2. Mixed tread was observed in band 3. A clear decrease in reflectance up to 50 percent was observed when water storage depth increase up to 90 cm but then it started increasing. Similar variation was observed for observation with a depth of more than 1 m. Satellite data is more stable as compared to GTR data.

Keywords: Remote sensing; spectral response; water storage; water available.

1. INTRODUCTION

Water is an essential inorganic solvent for the survival of living body and also a natural resource with both ecological and economic value and is of vital importance for sustaining life, health and integrity of ecosystems [1]. The availability of water is extremely uneven, both spatially and temporally and so will be the case in the future with continuous increase in population and shrinking of natural resource, the demand of water resources has been increasing for enhancing agricultural production. More than 70 percent of population use for domestic needs and also more than half of irrigation needs are met from this source [2]. Prediction of water depth in water bodies is one of the challenging task in this concern. The water depth in any water body should be measured accurately to estimate the total quantum of available water at any point of time.

Measurement of water depth in various water bodies by traditional method is time consuming, expensive and labour intensive [3]. Traditional techniques provide only point data, where measurements of reflected energy are obtained at many locations on one or many water bodies such as lakes, or reservoirs. Currently, remote sensing data is being used widely for land use classification, which also includes class of water body [4,5]. It will be further useful if quantity of water available can also be estimated. Applications of Remote Sensing technique have been applied to predict the water depth in water body [6]. Remote sensing is an economical way to monitor water bodies, because it can monitor large areas in a short time on a repetitive basis [7]. It is also easy to update remote sensing data, which allows continuous monitoring [8,9]. Resource managers are therefore interested in using such data. It is an economical way to monitor large areas repeatedly [10]. Therefore, it needs intensive ground truthing of the area concerned and gathering information about depth of storage to establish relationship between spectral reflectance and depth of water. In the present study, efforts are made to develop the relationship between change in reflectance with respect to water depth storage in the field and wetness at any time [11,12]. It is therefore necessary to understand the spectral reflectance over these situations. Intensive observations are required on spectral characteristics of these land situations. Present study is planned to characterize these situations with close observations of spectral response in standing water depth.

2. MATERIALS AND METHODS

2.1 Experimental Setup

The study was conducted in experimental plots near College of Agricultural Engineering, J.N.K.V.V. Jabalpur (M.P.). The experiment was conducted in one plots having clay soil (plot no. 31). The experimental setup is shown in Fig. 1.

2.2 Hand Held Spectro-radiometer

Hand held spectro-radiometer is used for taking spectral reflectance of different soil at various water levels and moisture content. It is well established fact that remote sensed in situ spectral signature data in different parts of the electromagnetic spectrum helps to classify/identify different terrain surfaces/objects. Space Application Center Ahmadabad, India has designed and developed four bands spectro-radiometer. The four bands operate in the visible and near infrared region (i.e. from 0.4nm to 1.1nm) to meet these requirements. The instrument is useful for quantitative measurements of visible and near I R radiation.

2.3 System Description and procedure

1. The function at block diagram of the instrument is shown in the Fig. 2. The optical head and display units are the two sub- systems of the instruments. The optical head is mounted in such a way that incident radiations are allowed to fall on the lens of optical head.

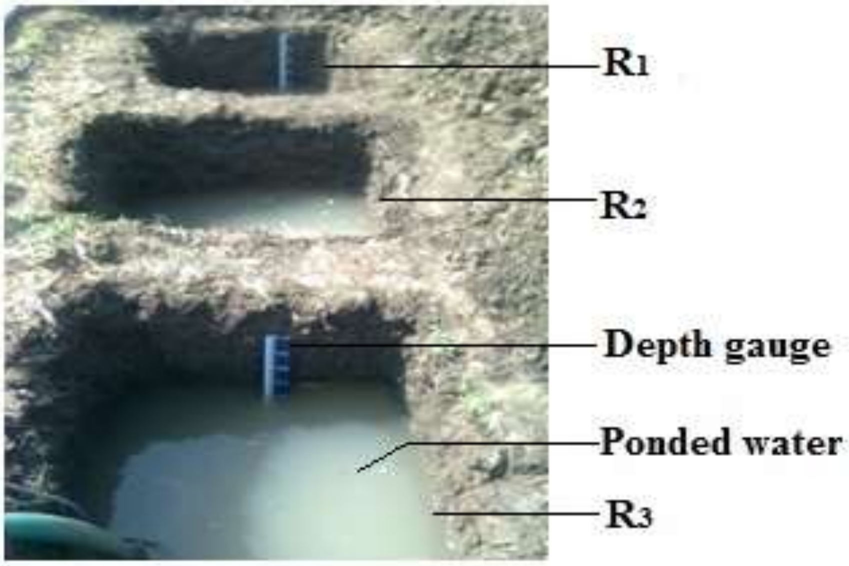


Fig. 1. Gauging of ponded surface in clay soil

2. One of the spectral bands is selected out of the four pre selected spectral band through range selection to ensure proper measurement accuracy and offset adjustment to nullify initial radiation conditions. It is the only control mounted at rear pane of optical head.
3. The output corresponding to input radiation level at selected spectral band is observed on the display unit. This output is in the units of w/cm^2 -Sr-micron. Then, it is multiplied by a decode factor indicated on the range select control.
4. A silicon photodiode with built in low noise current mode operational amplifier is incorporated on to the detector with the help of an achromatic outlet lens. Appropriate spectral band is achieved with the help of interference filters which are mounted in the freely rotatable wheel.
5. A special calibration electronics is incorporated which essentially consists of voltage divider network. Due to simultaneous action of changing of interference filter and a separate voltage divider meant for each spectral band, a direct calibrated quantitative value of spectral band is achieved. The output is monitored on 3½**"** digital panel meter.
6. Ground truth radiometer calibration plate is provided along with the units. This plate was coated with $BaSO_4$. It reflects 100% radiation. Percentage reflectance with respect to the 100% reading obtained from the GTR calibration plate is calculated.

2.4 Calibration

After connecting the power supply i. e. battery to the main display unit, the input unit, is connected to the output to be displayed via, display unit with the help of the cord provided. The range select knob is kept to 10^{-12} w/cm^2-Sr-micron and sensitivity range select knob at 10^{-5} sensitivity range because it is the most sensitive to the incoming radiations. Then adjust the zero select knobs so that the display unit reads 0.00. This completes the calibration part of the process.

2.5 Measurement of Reflected Energy

The lens cover of optical head is to be removed for taken spectral reflectance of the various objects [13] Fig. 3. Zero select knob is first placed zero at position to take the spectral response of the plate. Hand held spectro-radiometer is kept at 1m height above the ground and observations were taken on the ½ cercal cover [14]. This process was repeated for the other three bands. Observations were taken for different objects such as dry soil, wet soil and water body in this manner at different depths of water and moisture content between 10:00 AM to 11:30 AM.

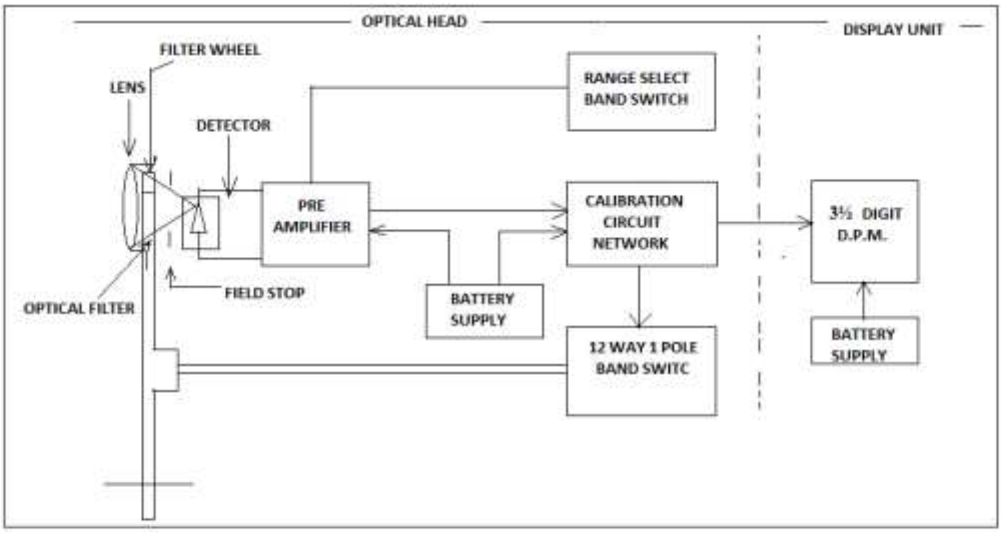


Fig. 2. Block diagram of hand held spectro-radiometer

(a) (b) (c)

Fig. 3. Measurement of reflected energy (W/cm^2 Sr-micron), (a) Ground truth radiometer (GTR), (b)Total energy Calibration plate ($BaSO_4$), (c) Observation on object

2.6 Time of Obserzvation

In the morning 10:00 AM - 11:30 AM was fixed for measurement. This time segment was selected after many experiments on the water pool. Reading was taken by filling 10 cm or discharging 10 cm each time. All readings were recorded with discharging of 10-10 cm water from pool. Each observation was recorded in three replications.

2.7 Computation of Reflectance

Reflectance is defined as a ratio of reflected energy on object to reflected energy on plate [15]. It is given below as,

$$\text{Reflectance \%} = \frac{\text{Reflected energy on object}}{\text{Reflected energy on plate}} \text{ X } 100$$

Reflected energy (W/cm^{2}Sr-micron) in band, 1, 2, 3 and 4 for plate and on water storage in soils were collected for all replication. Similarly observations on reflected energy were recorded (W/cm^{2}Sr-micron) for 12 to 15 days in clay and clay loam soils. The observations were continued for drying soil up to dry condition.

3. RESULTS AND DISCUSSION

3.1 Average Response for Ponded Water

Looking the average reflectance in different four bands and its variation with different depth of ponding in Fig. 4 it can be said that as depth increases, percentage reflectance decreases in all bands. The maximum value of reflectance has been found as 65.9% with 20 cm depth (band 1) when as the minimum of 32.2% was observed at a depth of 80 cm depth (band 2) of ponding. Second band gives a linear decrease in percent reflectance as increases in depth but remaining three bands are fluctuating as percent reflectance but decreases as per increase in depth. Band third and fourth gives its maximum percents reflectance at depth between 40 to 60 cm.

3.2 Correlation Analysis among Responses with Different Depths

The different spectral response mean water depths showed significant influence upon this parameter. Treatment on 20 cm depth proved equally most effective and significantly superior over all remaining other depths at a band 1. But 30 cm at band 2 presents the significant difference with 40 cm to 100 cm depth. Band 3 shows that 50 cm is significantly different in all depth of water body. Similarly band 4 in 50 cm and 100 cm depth. Hence results obtained in band 3 and band 4 similar but band 1 and band 2 are different Fig. 4.

3.3 Spectral Response at Higher Depths of Storage

The experiment was conducted on the pond located on Adhartal agricultural farm whose water level depth ranges between 1m to 6m the was taken in four bands of GTR, the reflectance value is tabulated in Table 1. The values of reflectance were plotted with depth and presented in Fig. 5. It is clear that when the depth of water is more than one meter then reflectance variation mostly become constant.

Similarly response was obtained for the observations through the satellite LISS-III, IRS-P6 for Adhartal agricultural pond as shown in Fig. 6.

3.4 Comparison between Ground Observations and Satellite Data at Deep Water Body

A comparison between ground data and satellite data of indicate the trend of variation is similar in band 2 and band 4. In band 1, there is a deviation in trend of satellite data with that of actually observed through ground truth radiometer. In Band 3 the satellite data shows a steeper gradient than that of the ground observations (Fig. 7).

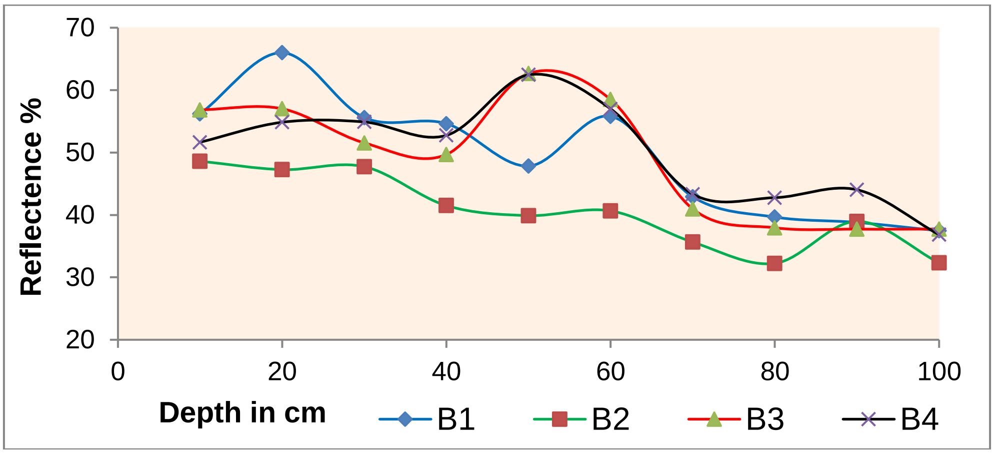


Fig. 4. Spectral reflectance of ponding water in clay soil (B_1 to B_4)

Table 1. Ground observation of reflectance value with deep water body

Depth	B1	B2	B3	B4
1m	78	67	86	86
2m	89	69	79	91
3m	82	74	84	89
4m	79	85	91	97
5m	90	83	93	91
6m	81	60	68	80

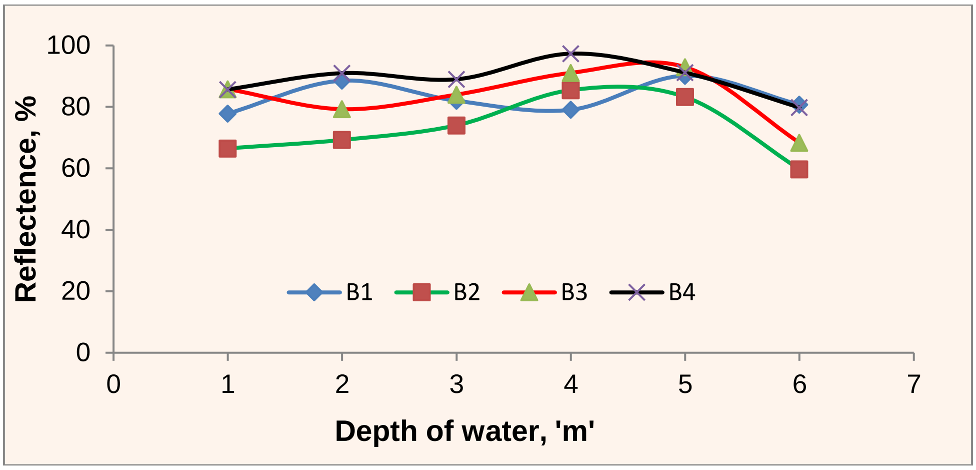


Fig. 5. Reflectance of deep water body (Ground observation)

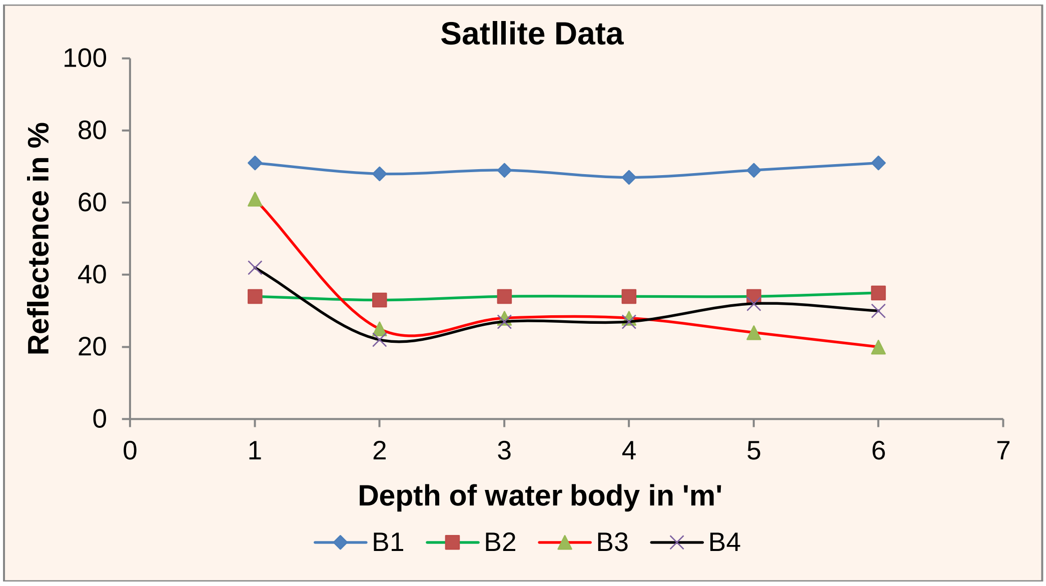
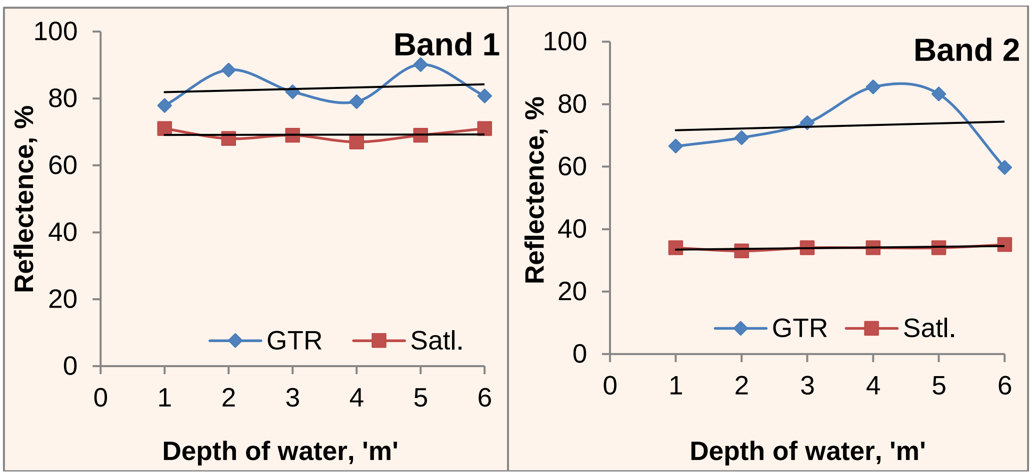


Fig. 6. Reflectance at different depth of storage through satellite



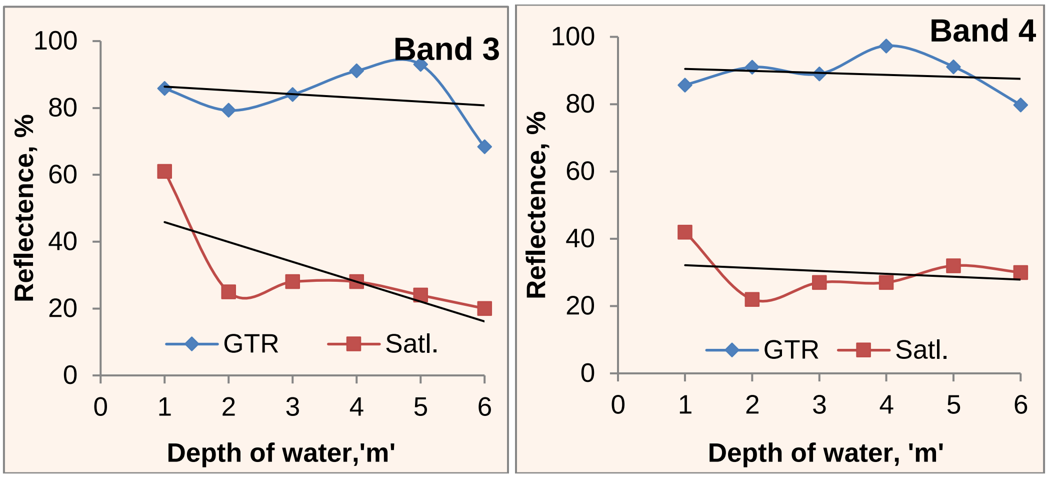


Fig. 7. Spectral response using GTR and satellite

However the reflectance value which ranged from 74 to 97 percentages in ground observation, changes from 22 to 71 percent in satellite image. The difference may be because of the atmospheric interaction of energy reaching to ground and being received by the satellite and that of the ground truth radiometer sensors. It may be infrared from the data that spectral response may differentiate lower depths (2m and below) and higher depths (above 2m) clearly and not beyond that.

4. CONCLUSION

Reflectance decreases with increase in depth of stored water. The spectral responses of different depth of water are similar for both conditions of ponding-surfaces i.e. clay and clay-loam soil. There is some variation between the bands at same depth. Statistical analysis shows that spectral response with 20 cm water depth is significantly different in all different water depth (10-100cm) experimented.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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