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APPLICATIONS OF REMOTE SENSING: A REVIEW

PRADNYA R MAHESHMALKAR[1*], SHIVANAND V KSHIRSAGAR[1], SHAFIYODDIN B SAYYAD[2], KIRTI R DESAI[3]

[*, 1] Department of Physics, Mrs. K. S. K. College, Beed, 431122, India, [2]Milliya College , Beed, 431122, India, [3]Art's Commerce and Science College, Kille Dharur Beed, 431122, India. Email: pmaheshmalkar4@gmail.com

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ABSTRACT

Objective: This paper presents a comprehensive review of the basic principles of the microwave remote sensing technique, Capabilities of microwave sensors for the remote sensing, several studies of Applications of Remote sensing and the status of current methods. The spectral characteristic of the main earth surface feature is Soil Radiation interaction characteristics of earth and atmosphere in different regions of electromagnetic spectrum are very useful for identifying and characterizing earth and atmospheric features. It gives the information needed for soil management programs in order to satisfy the environmental conditions. The principle objective of this review is to present particularly soil studies based on Remote sensors.

Materials and Methods: Remote sensing measures electromagnetic radiation that interacts with the atmosphere and objects. Remote sensing is considered a primary means of acquiring spatial data. The Remote Sensing is a multi-disciplinary science. Remote sensing uses the entire electromagnetic spectrum, ranging from short wavelengths (for example, ultraviolet) to long wavelengths (microwaves). The characteristics of soil that determine its reflectance properties are its moisture content, organic matter content, texture, structure and iron oxide content.

Results: Interactions of electromagnetic radiation with the surface of the Earth can provide information not only on the distance between the sensor and the object but also on the direction, intensity, wavelength, and polarization of the electromagnetic radiation.

Conclusion: Recent technological advances in satellite remote sensing have helped to overcome the limitation of conventional soil survey and providing a new outlook for soil survey and mapping.

Keywords: - Soil Properties, Microwave remote sensing

INTRODUCTION

There are different types of soil on earth. Soil quality is estimated by observing or measuring several different properties or processes. Remote sensing has proved to be an important part of soil study. Remote sensing is the process of detecting and monitoring the physical characteristics of an area by measuring its reflected and emitted radiation at a distance (typically from satellite or aircraft).

Special cameras collect remotely sensed images, which help researchers "sense" things about the earth. A Simple example of a remote sensing instrument is a photographic or digital camera. A camera records energy in the form of of light that is reflected from a surface to form an image.

Output can constitute an effective means of monitoring soil moisture of the land surface. The physical basis of remote sensing depends on the inference of land surface characteristics from the measurement of the emitted or reflected electromagnetic radiation from the earth. Remote-sensing technologies have been applied widely in environmental monitoring, agriculture, climate change detection, flood prediction, mapping and so on. Microwave technology has demonstrated a quantitative ability to estimate soil moisture physically for most ranges of vegetation cover.

Satellite remote sensing consists of one or multiple remote sensing instruments located on a satellite or satellite constellation collecting information about an object or phenomenon on the Earth surface without being in direct physical contact with the object or phenomenon.

The active techniques provide opportunities for soil moisture studies over a large area, so that soil moisture information can be obtained on a local as well as a global basis. Soil moisture in the upper part of the earth's surface has been recognized, as a key variable in numerous environmental studies. Soil moisture is an important variable in many hydrologic, agricultural and meteorological applications. The majority of radiation incident on a soil surface is either reflected or absorbed and little is transmitted .The fundamental knowledge about the electromagnetic spectrum and the interaction of objects and the spectrum helps to understand that when a sensor is operated in a certain wavelength how environmental objects will react to it. The recent progress in several of these areas will be documented in this review. There are a variety of techniques like Optical Remote Sensing, Thermal Infrared Remote Sensing, Visual Image Interpretation, Microwave Remote Sensing, and Hyper spectral Remote Sensing by which soil survey and mapping can be carried out. Microwave remote sensing of soil moisture has been an active area of research.

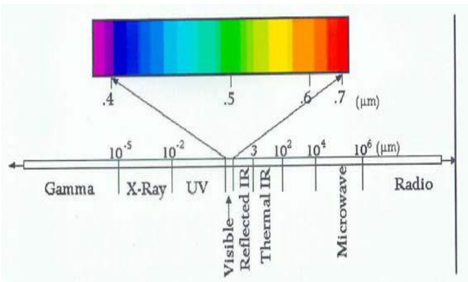

Fig.1. Electromagnetic Radiation(EMR) and Remote Sensing

Literature Review

Several research studies showed that, the microwave radiation penetrates slightly within the ground and volume effects influence soil microwave emission. The soil moisture content is also important for predicting runoff following a rain event. The remotely sensed measures of soil moisture were as good as several ground based methods in a small watershed for runoff predictions. It should be possible to use the remotely sensed measures in areas without extensive ground measurements to improve the prediction of runoff. Passive microwave radiometry appears to be a promising tool that addresses the fundamental needs in atmospheric and hydrological models for land surface characterization at a regional/global scale on a daily basis [1].

Soil moisture is one of the few directly observable hydrologic variables that play an important role in water and energy budgets necessary for climate studies. Thus, microwave approaches could not be use to readily determine soil moisture in forested regions. The soil properties, which affect the microwave response, include density and texture; these factors will change the sensitivity but do not reduce the range of the soil moisture effect. Surface roughness can reduce the range of the microwave response by as much as half in extreme situations, but the more common effect is perhaps a 10 or20% reduction in sensitivity. Also, surface roughness and density are factors which will remain relatively constant due to infrequent working of agricultural fields. These basic conclusions have been verified with measurements from field towers, aircraft and to a limited extent satellite platform [2].

The microwave emission from objects is primarily dependent upon the objects physical temperature and its dielectric properties (i.e. their frequency dependent radiative /absorptive properties). The dielectric properties are related to the physical make-up of the object: i.e. the materials it is made from. For most practical applications of passive imagers (for land observation and sea ice) the most significant factors affecting the measured intensities are temperature, salinity and liquid water content. The surface roughness also has an influence on the directivity of the emission [3].

The presence of moisture in soil decreases its reflectance. By measuring the energy that is reflected by targets on earth's surface over a variety of different wavelengths, we can build up a spectral signature for that object. In addition, by comparing the response pattern of different features we may be able to distinguish between them, which we may not be able to do if we only compare them at one wavelength. For example, Water and Vegetation reflect somewhat similarly in the visible wavelength but not in the infrared [4].

Methods of passive microwave sensing of soil can be used to retrieve the type, wetness and wetness profile of a soil, to map ground waters, etc. This information is helpful in the solution of many problems such as river flood forecast, harvest estimations, irrigation planning, and meteorological modeling. However, considerable difficulties arise when interpreting data of soil remote sensing. Their origin lies in the great variety of existing soils (different structural and mineral content) as well as in the complexity of a soil (first of all, the presence of bound and free water and its distribution amongst soil particles). To overcome those difficulties, it is necessary to develop an applicable electrodynamics model of soil taking into account its real physical and structural properties [5].

On the interaction of sensors with the environment, typical examples in glass, metal, water, soil, and vegetation were provided. Remote sensors were presented in terms of imaging sensors and non-imaging sensors. Optical imaging sensors and thermal imaging sensors, radar imaging sensors, and laser scanning were highlighted. In addition, commonly used remote sensing satellites, especially those from NASA and ESA, were detailed in terms of launched time, sensors, swath width, spectrum bands, revisit time and spatial resolution [6]

On the basis of the active remote sensing methods, estimating soil moisture on bare soil or soil with less vegetation gives more accurate results, as compared to using the methods on a mixture of land-cover soil. Moreover, the estimation process becomes more challenging when the vegetation cover is dense. From the other side, under similar soil cover conditions, estimating soil moisture using a combination of both active and passive remote sensing information gives accurate results. Other hand, in situ soil-moisture measurements provide deep layer soil moisture estimation and are considered as the standard measurements for soil-moisture estimation. Among field methods, the standard method of measuring the soil moisture content is the thermo- gravimetric method. The advantages of this method are that it is inexpensive and soil moisture is easily calculated. The basic conclusion of this review paper is that remote sensing combined with field methods provide distributed soil profile moisture information. It is recommended to carry out detailed research work applying both remote sensing and field measurements for soil moisture estimation [7].

Remote sensing is one of a set of tools available to land managers that provides up-to-date and the detailed information about land condition. It provides a cost-effective technique for mapping and monitoring broad areas. The uniqueness of satellite remote sensing lies in its ability to show large land areas and to detect features at electromagnetic wavelengths, which are not visible to the human eye. Data from satellite images can show larger areas than aerial survey data and, as a satellite regularly passes over the same plot of land capturing new data each time, changes in the land use and condition can be routinely monitored. The information from remotely sensed images can be used in a number of ways for a number of purposes. It is usually combined with information from other data sources and on-the-ground observations, called ground truth.

Because of some limitations by traditional measurement methods, microwave remote sensing has been the most effective tool to monitor the soil moisture. The betterment of agriculture depends on various environmental parameters such as soil temperature, soil moisture, relative humidity, pH of soil, light intensity, fertilizing property of the soil, etc. Any small changes in any of these parameters can cause problems like diseases, improper growth of plant, etc. mainly resulting in lesser yield.

There are number of techniques of doing the remote sensing for crop growth, vegetation growth and other related study for harvesting. On-field & Off-field sensors to estimate surface soil moisture information using remote sensing as follows have used the various methods:

Use of technology in the field of agriculture plays important role in increasing the production as well as in reducing the extra manpower efforts, water requirement and fertilizer requirement.

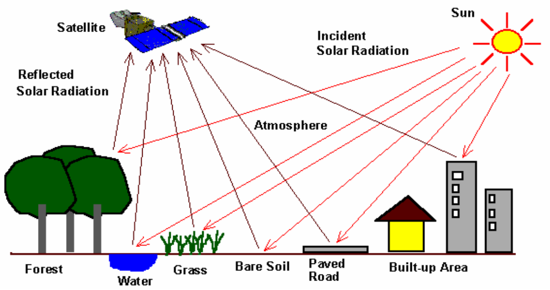

Fig. 2: Basic diagram of Optical Remote Sensing

Optical remote sensing makes use of visible, near infrared and short-wave infrared sensors to form images of the earth's surface by detecting the solar radiation reflected from targets on the ground. Different materials reflect and absorb differently at different wavelengths. Thus, their spectral reflectance signatures in the remotely sensed images [8] can differentiate the targets.

Among the various soil properties, Soil salinity is one of the major soil degradation problems that affect crop growth and productivity. The identification of typeand severity of salt affected soils with their location and areal extent is necessary for reclamation of the salt affected soils. Radar is known to be sensitive to several natural surface parameters such as vegetation, surface roughness and dielectric Constant.

Spatial variability of soil texture and hydraulic parameters could be assessed usingtemporal microwave remote sensing derived changes in brightness temperature and soil moisture content.

Soil surface roughness (SSR) has influences on soil thermalproperties, infiltration rate, surface run-off and susceptibility ofsoil to erosion.Spatial and temporal variations in SSR can result from natural or anthropogenic phenomena, including tillage, erosion, raindrop impact.

Soil drainage is important as it directly affects plant growth, water flow and solute transport in soils. Drainage refers to the natural ability of soil to allow water to infiltrate and percolate. Drainage mapping is of interest because soil map users usually need information about soil properties or soil behavior rather than taxonomic classes for land use and management decision. For microwave remote sensing, the magnitude of radar backscattering from a soil surface is governed by the dielectric constant and soil surface roughness The dielectric constant in turn, is dependent strongly on soil moisture content and, to some extent, on soil texture composition. Therefore, radar remote sensing has the potential to map soil properties, such as soil drainage.[9]

Various properties of soil can be mapped with the help of remote sensing. Optical remote sensing helps in the mapping of properties like land cover, land type, vegetation and soil moisture. Thermal infrared remote sensing is commonly used to estimate moisture and salinity. Visual image interpretation technique helps in the identification and mapping of soil elements like land type, vegetation, land use, slope and relief. Microwave remote sensing is a new and effective technique for mapping of soil moisture and salinity, which is being commonly used today. Hyper spectral remote sensing is another recent method, which is applied in soil salinity mapping as well as identification and mapping of minerals in the soil. [10].

Satellite data offer tremendous advantages for irrigated area mapping problems at various temporal and spatial scales. However, for more effective use of remote sensing, the analyst should be aware of the limitations and advantages of satellite data and should choose from the available irrigation mapping options accordingly. Machine learning and rule-based classification methods generally provide better results than conventional statistical classification approaches. If detailed information is required at a finer spatial resolution than the satellite sensor can provide, then a sub pixel classification scheme should be used. Several methods have been developed for this purpose. In conclusion, mapping of irrigated areas with satellite imagery is difficult but possible. As with many remote sensing problems, satisfactory results may require techniques specific to the location on a case-by-case basis. Finally, multi sensor data fusion provides an effective paradigm for remote sensing applications by synthesizing data from multiple sensors or sources [11].

Large amount of effort has been made for management of resources and land use. The direct measurement of this parameter is done in the field or by analyzing soil sample under laboratory condition. There are a number of methods available for point measurement, for e.g., techniques, like gravimetric methods, nuclear methods, scattering, electromagnetic methods, tensiometer techniques, hygrometric techniques and emerging techniques. soil moisture sensitivity decrease significantly due to the presence of these noise parameters in a resolution cell. [12].

Direct observations of soil moisture are currently restricted to discrete measurements at specific locations, and such point-based measurements do not represent the spatial distribution because soil moisture is highly variable both spatially and temporally [13].

From the physical and chemical characteristics of the soils studied, it has been found that the soils of the area are exposed to degradation in the surface and sub surface horizons in all the lowland areas and non-saline and nonsodic in both upland and midland areas. Maximum low land area had higher sub surface sodicity than surface horizon. Maximum upland areas are exposed to water erosion and Maximum low land area are exposed to salinization, alkalinization, and physical degradation [14].

Satellite remote sensing offers tremendous potential for routine monitoring of irrigation due to the synoptic nature of the data and readily available archives of imagery.

In comparison to active microwave, the passive microwave has more potential for large-scale soil moisture monitoring, but has a low spatial resolution.

CONCLUSIONS

It can be concluded that, Soil survey constitutes a valuable resource linked with the survival of life on the earth. The technological advancements in the field of remote sensing have been a support for such surveys for mapping and characterizing soils at various scales. Information of soil properties is required for various purposes of sustainable agriculture development and management. The status of microwave remote sensing techniques (active and passive) for spatial assessment of soil quality parameters such as soil salinity, soil erosion, soil physical properties (soil texture & hydraulic properties; drainage condition); and soil surface roughness. Recent technological advances in satellite remote sensing have helped to overcome the limitation of conventional soil survey and providing a new outlook for soil survey and mapping. To keep the environmental balance of various sources of the earth, this modern approach will helpful.

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