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Study calcareous soils behavior in different climatic conditions based on their spectral signature

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Abstract

Lime and gypsum are among the compounds that give clear indicators when monitored by remote sensing devices and techniques, and since they are present in agricultural soils significantly in arid and semi-arid regions, lime was considered one of the indicators that can be monitored in the soil. Accordingly, four areas were chosen to study the spectral reflectivity of their surface soils under somewhat different climatic conditions, which are the northeast of Dohuk, Al Sherekhan, the village of Balak Qout, and the University of Mosul. They represent the soils of agricultural areas. Representative samples of the soil were taken for each study area, and the value of calcium carbonate was measured, and three levels of soil particles were made for each sample, which are grinding soil in the form of powder, and aggregates of soil particles with a diameter of 2 mm, and aggregates of soil particles with a diameter of 4 mm. After that, the reflectivity of the flat surfaces of these samples was measured using a spectrometer. The results showed a superiority in the spectral reflectivity values between the sizes of the diameters of the soils, as the highest reflectivity of the soil was of soft sizes, then the largest size, then the largest, and that the carbonate content had a clear effect in raising the spectral reflectivity ratios in all locations with the overlap in the amount of reflected rays due to the dispersion that occurs, due to the surface roughness of the samples with larger diameters.

Keywords: Soil; Reflectivity; Remote sensing; Calcareous; Climatic conditions

1. Introduction

Soil is defined as a natural, developed body that has physical, chemical and vital properties. Perhaps one of the most obvious physical characteristics is the color of the soil, which can be differentiated directly from other soils according to the experience of workers in this field, as well as the use of a color atlas to give descriptive quantitative values for color, but things are not stands at this point, with the development of studies and the increase in technology. The evaluation relied on what is wider than visible light, which is a small package of the electromagnetic spectrum that increases the capabilities of discrimination and separation, and that there are many factors affecting the soil color that may give overlapping color characteristics, including: soil moisture, salt content, minerals, in addition to the presence of gypsum and calcium carbonate. And the adoption of all these things in an overlapping manner may not give a clear indication of the reason affecting the color of this soil, so it was adopted in this research to choose one characteristic of the soil taken as a criterion for the difference in color with the concentration of this characteristic, and perhaps the most obvious characteristic is the soil content of calcium carbonate, which forms Finally, calcic soils.

Calcic soils are defined as soils that contain an amount of calcium carbonate at a level that affects the physical and chemical properties of the soil and thus its impact on the nature of its agricultural use (Land use) [1]. These soils can be monitored with the naked eye while digging soil profile, as well as by distinguishing them from their surroundings using

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remote sensing techniques, as well as the reflective behavior of their distinct spectral signature. The same researcher pointed out that these carbonates are often found in one or more calcic soil horizons that develop in arid and semi-arid regions and areas with a Mediterranean climate or dry desert climate, these areas are characterized by long dry seasons that are not suitable for deep leaching of these soils, in addition to the nature of the rocks that make up the prevailing geological formations, which are often limestone rocks or rich in calcium carbonate.

Abtahi and Khormali [2] when studying the calcareous soils of arid and semi-arid regions in southern Iran indicated that calcium carbonate in the soil may sometimes be present in the form of calcareous nodules that may be of pedogenic or geological origin, airborne or waterborne, which is considered one of the characteristics It is common for calcareous soils formed under arid and semi-arid conditions, as indicated by Khormali and Abtahi [2] that the moisture content of the soil plays a "major" role in the pattern and distribution of carbonates in the form of nodules.

Remote sensing has recently been defined as measuring objects and their characteristics on the surface of the earth, using aircraft and satellites and their acquired data without direct contact with the desired object, relying on repeated optical signals as well as thermal radiation [3]. Among the things that remote sensing monitors are: the study of forests, the monitoring of agricultural crops, desertification, land degradation, land use and soil classification, depending on the spectral reflectivity of those monitored targets including soil.

It must be noted that remote sensing technologies are not a substitute for any technology or traditional method in the study of agricultural resources, but rather a supportive tool and a complementary method applied in the agricultural sector and other sectors to quickly reach positive results that help planners and decision makers to develop plans for continuous comprehensive development. Therefore, the need has become necessary and urgent to take advantage of this technology, due to the natural resources suffering from environmental disasters and desertification processes that have spread in recent years throughout the world.

Soil reflectivity can be studied using the spectroradiometer by knowing the spectral behavior in each band and comparing the variation in reflectivity under the influence of several factors, including the local climatic factor for each microclimate.

It can be seen that the dry soil has a less complex reflective behavior than that of the plant, where the degree of reflection increases with the increase in wavelength, due to the degree of reflection with the increase in wavelength, because of absence of energy transmission through the soil, and therefore the energy that is not absorbed It will be reflected, but there are a number of factors that determine the amount of reflection. These factors are soil texture, salt content, soil moisture content, soil content of organic matter, soil content of iron oxides. The spectral reflectivity, or spectral signature of objects can be defined as the amount of reflectivity recorded for those materials by sensors carried on air or space platforms, and then the pattern and condition of those objects can be estimated [4]. The reflective properties (spectral reflection coefficient) of an object on the surface of the earth are measured by the part of the energy reflected from the surface of the object studied for any wavelength or beam to the total electromagnetic energy falling on it in the same wavelength or beam, and this ratio is expressed as a ratio confined between (0-100) %. The beginnings of the current century witnessed the publication of many researches related to the spectral signature of a large number of soils and linking them with the physical and chemical properties of these soils, such as relationship study between spectral reflectance values and soil content of calcium carbonate [5]–[7] the presence of white calcium carbonate in the soil may lead to an increase in the rays reflected from soil surface, and thus calcareous lands appear white or light color satellite image or prepared in black and white.

Al-Hunaidi and Al-Mesber [8] showed in a soils study of the eastern Al-Hayr Plain of calcium carbonate using remote sensing techniques through the Landsat 7 ETM satellites that the spectral reflections of surface soil samples containing calcium carbonate by spectroradiometer produced a high reflectivity percentage, and that the spectral range B1 was the best predictor of soil calcium carbonate content.

A study was conducted by Bahlawan [9] in which he determined the spectral behavior of some calcareous and gypsum soils in the laboratory without addressing the determination of the best equations for predicting the soil content of gypsum or calcium carbonate in the different spectral ranges of TM data or ASTER data, and he found that the spectral behavior of calcareous soils differs from the spectral behavior of gypsum soils.

The current study aims to know the spectral reflective properties of the soil depending on the percentages of calcium carbonate content in the soil, and for the purpose of achieving the objectives of the study in measuring reflectivity, the ASD Spectroradiometer and the touch probe method were used to measure the spectral reflectivity properties within different wavelengths.

2. Material and methods

Four locations were chosen to study the spectral reflectivity of their surface soils under somewhat different climatic conditions, namely (northeast of Dohuk, Al Sherekhan, Balak Qout village and University of Mosul), where there coordinate in table (1).

Table 1 Coordinates of the study sites

No.	Locations	North	South
1	northeast of Dohuk	37° 02′ 52.27″	43° 20′ 5.66″
2	Al Sherekhan	36° 24′ 25.64″	43° 04′ 4.07″
3	Balak Qout village	36° 23′ 54.16″	42° 26′ 40.82″
4	University of Mosul	36° 22′ 54.55″	43° 08′ 7.00″

The first site represents lands cultivated with the wheat crop in northeastern Dohuk, and the second site represents lands of orchards close to the river in Al Sherekhan, while the third site is about rangeland soils in the village of Balak Qout, and the fourth site is about soil samples taken from agricultural lands within the borders of the University of Mosul from college of Agriculture and Forestry, to represent the city center, as in Figure (1).

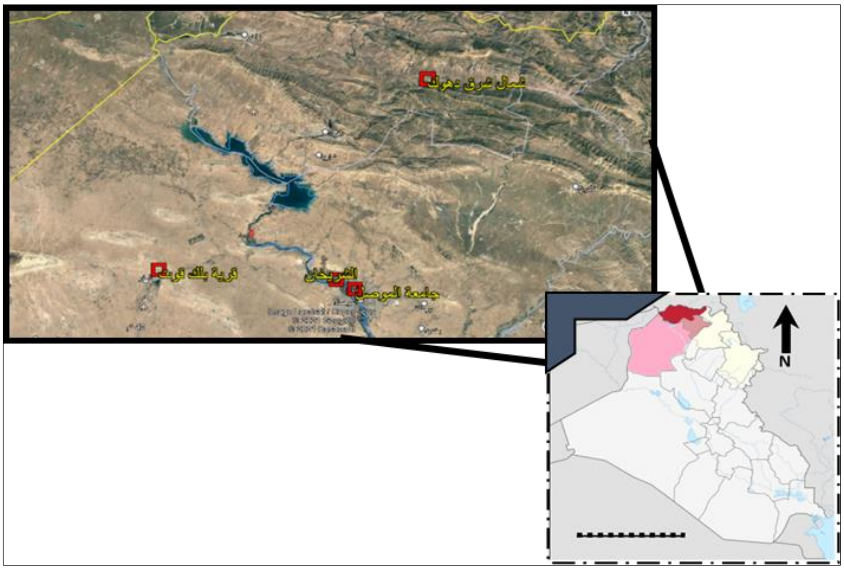

Figure 1 study locations

Surface soil samples were collected from the study sites at a rate of 10 samples and at different distances to make a composite sample that represents the concerned site and placed in plastic bags for the purpose of bringing it to the laboratory as it was air-dried and then the soil was dismantled and ground with a wooden hammer. Then the samples were divided into three parts, the first part was grinded using a grinding device prepared for this purpose, the second part was passed through a sieve with a diameter of 4 mm, and the third part was passed through a sieve with a diameter of 2 mm for the purpose of measuring the spectral reflectance separately. Calcium carbonate was determined by the calcimeter method using hydrochloric acid (HCl) (1N), according to [10] in the laboratory of the Department of Soils / College of Agriculture / University of Duhok.

The spectral reflectivity of the surface samples of the study sites was measured in the spectrum laboratory of the Remote Sensing Center at the University of Mosul using a spectroradiometer of American origin of the type ASD (Analytical Spectral Devices), as the device measures within wavelengths between (350-2500) nm up to (1) nm. The samples were air-dried and ground and each sample was divided into three parts, the first part was ground into a powder form, and the second part was sifted through a sieve with a diameter of 2 mm, and the last part was sifted through a sieve with a diameter of 4 mm, then placed in dishes with a diameter of 8 cm, and a depth of 1.5 cm while maintaining a levelness the surface of the sample in each dish when measuring and crossing as a percentage relative to the white color, and the results were in the form of a curve and in multiple wavelengths, according to [11].

3. Results and discussion

The results of the study showed, as shown in Table (2), an increase in the values of calcium carbonate in the site of the village of Black Qout, represented by wheat fields, which are always cultivated compared to other sites, as it amounted to 144.8 g.kg-1, while the lowest content of calcium carbonate in the lands of the college reached 102.6 g.kg-1.

Table 2 Calcium carbonate values in the study sites

No.	Locations	The use	CaCO3 g.kg-1
1	northeast of Dohuk	rangeland	136.9
2	Al Sherekhan	orchards	115.5
3	Balak Qout village	wheat fields	144.8
4	University of Mosul	Research field	102.6

The reflectivity is one of the visual characteristics that reflect the behavior of the physical and chemical characteristics of the soil. Each soil has properties that distinguish it from the other, through the spectral signature. Most studies have shown that it increases with wavelength, but these increases vary from one soil to another. Therefore, the spectroradiometer was adopted to measure the spectral reflectivity of the surface layer of the study models, as the size of the particles had an important role in obtaining different reflectance's in each site, as it is noted from figures (2, 3, 4, 5) that the highest reflectivity of soils was in the first model (powder) and then followed by soil With a diameter of 2 mm, followed by a model with a size of 4 mm and for all wavelengths within the electromagnetic spectrum 400-2500 nm.

Noting that there is an increase in the reflectivity values in all soils with the increase of the wavelength, as the highest value of the reflectivity reached (0.85, 0.62, 0.59), respectively, at the wavelength of 1700 nm, noting the water absorption bands clearly at the wavelength 1900 nm. The reason for this is due to the moisture content in the soil being sensitive at this range of wavelength, as it has a lower value of reflectivity with increasing moisture content.

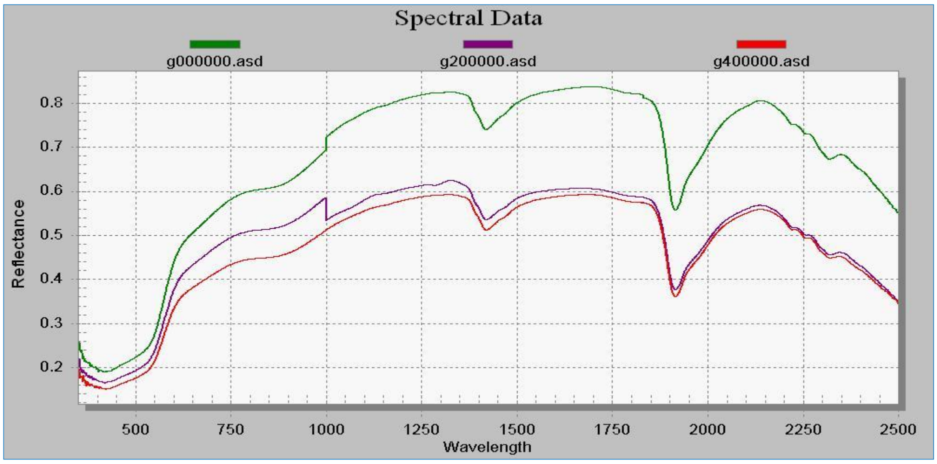

Figure 2 The spectral reflectance curve of the three sizes at the northeastern site of Dohuk

While it is noted from figure (3) that the highest value of reflectivity in the Sherekhan site reached 0.65 in the first model, while it reached 0.48 and 0.38 for soils with diameters 2 and 4, respectively, as is the case in the other two sites, figure (4) and figure (5), where the same approach was taken in the spectral behavior, as the reflectivity reached 0.54 for the first model in the college site, while the highest value of reflectivity in the first model for the Black Qout village site at the wavelength of 1000 nm was 0.73, and the reason for that is due to the high content of calcium carbonate in this region compared to the rest of the sites.

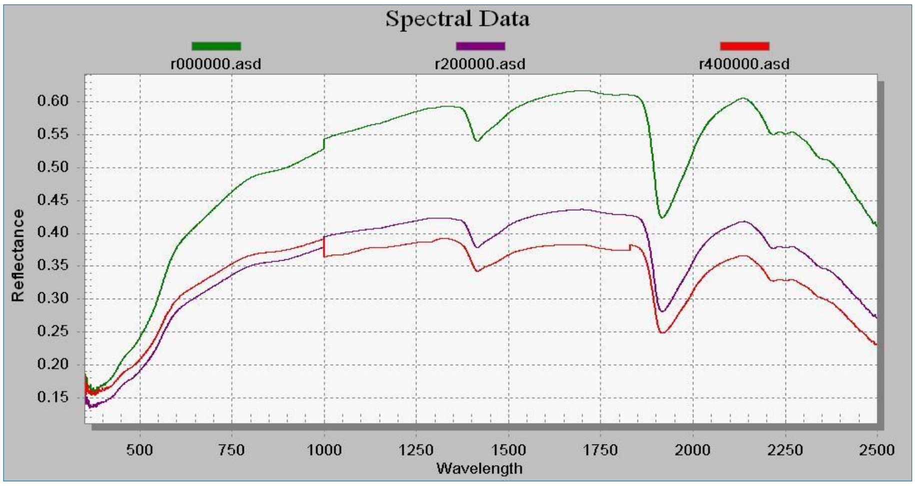

Figure 3 The spectral reflectance curve of the three sizes of Al Sherekhan

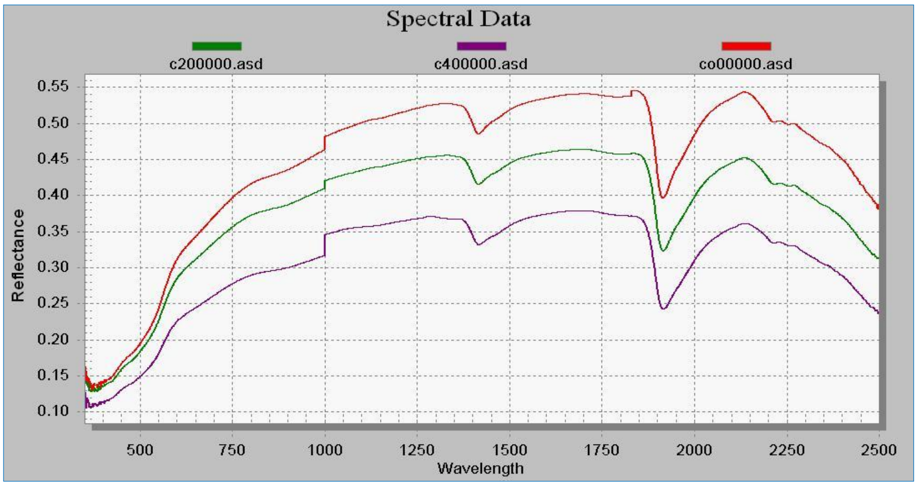

Figure 4 The spectral reflectance curve of the three sizes of University of Mosul

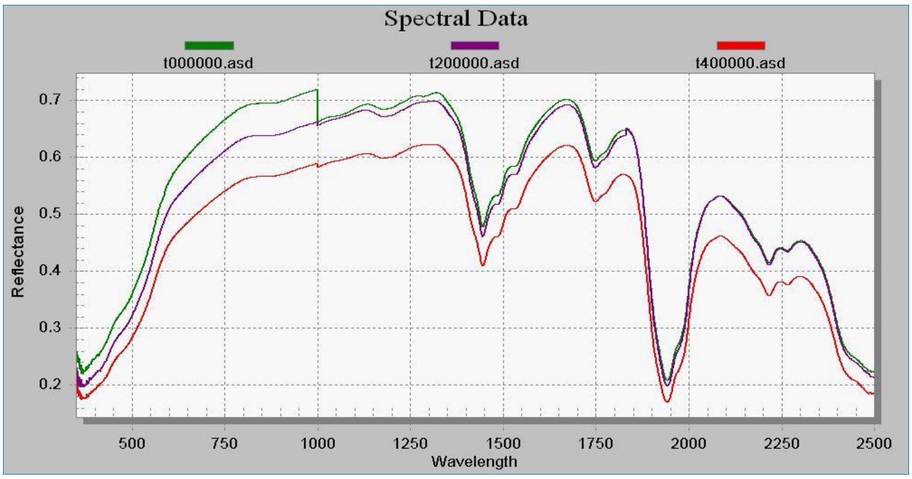

Figure 5 The spectral reflectance curve of the three sizes of Balak Qout village

When comparing the four soils with each other in the spectral behavior at the different spectral bands of wavelength and for each size separately, it was observed that the highest value of reflectivity appeared in the village of Black Quot up to the wavelength of 1000 nm, i.e. in the bands (1, 2, 3, 4) and the least reflectivity was at the site of the college, due to the high values of calcium carbonate in the village of Black Qout compared to other sites. The highest value of reflectivity was recorded in the rangeland soils in northeastern Duhok at the wavelength of 1700 nm, that is, in the fifth band, as the value of reflectivity was 0.85, as in Figure (6), because of the nature of the parent material in the region and its containment of high levels of iron oxides.

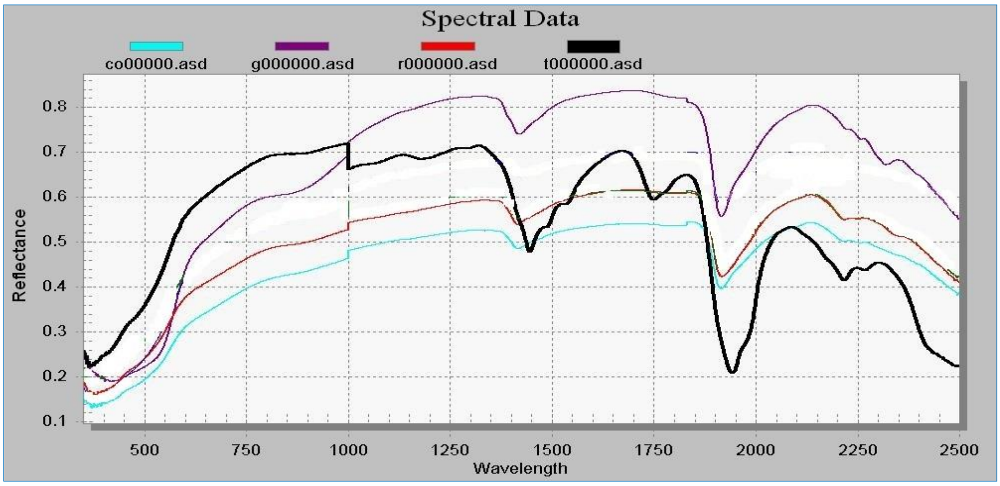

Figure 6 Soil spectral reflectance curves the study sites for the powder model

Figure (7) represented by the curves of soils with diameters of 2 mm shows that the highest value of reflectivity appeared in the village of Balak Qout at all wavelengths, followed by the rangeland area in the northeast of Dohuk, then Al Sherekhan and collage sites, and this corresponds to the values of calcium carbonate, as it was higher in the village of Balak Qout than the rest of other sites. We also notice a decrease in certain locations of the curves, especially for the 1400 and 1900 wavelengths, which represent the water absorption bands in the wavelength, and this is consistent. Also Figure (7) shows that the spectral behavior of soils with diameters of 2 mm was similar to soils in the form of powder in the reflectivity between the sites, as the soils sites of Black Qout village were higher compared to other sites with a difference in the reflectivity values, which may be due to the amount of And the dispersion difference between soil diameters, according to [4].

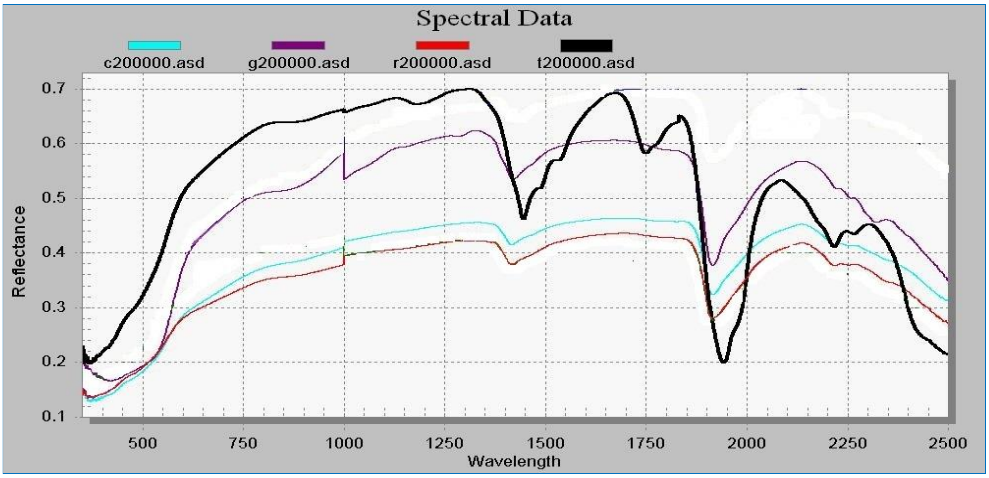

Figure 7 Soil spectral reflectance curves of study sites with a size of 2 mm

As for Figure (8), which is represented by the reflectivity curves of the 4 mm models, it showed closeness in the reflectivity values of the soils of the village of Balak Qout and northeastern Duhok due to their high content of calcium carbonate, because of their effect in reflecting almost equal amounts of all radiation waves used in imaging within the two fields. The visible and infrared spectrum, which is in line with the radiometric measurements that were made on the calcareous soils in the Al-Rabee Valleys area east of Damascus, and non-calcareous soils in the Al-Zabadani area [12].

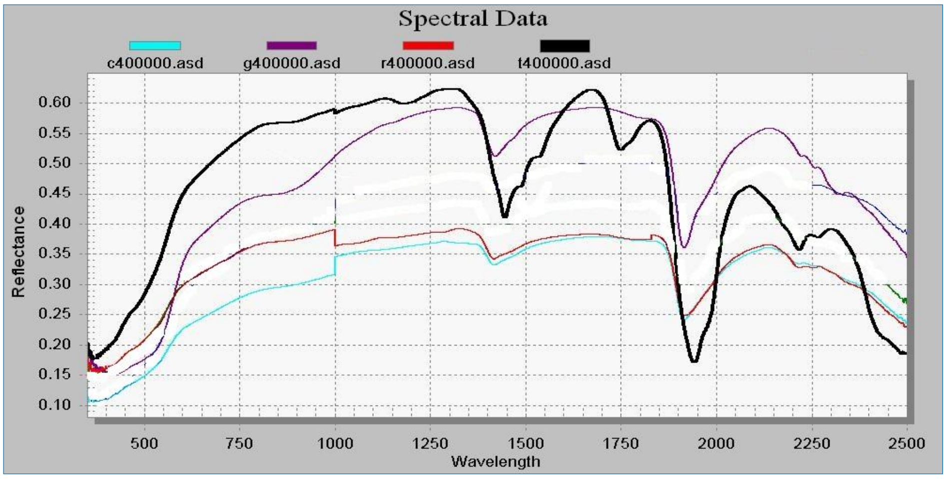

Figure 8 Soil spectral reflectance curves of study sites with a size of 4 mm

4. Conclusion

- The results of the study showed superiority in the values of spectral reflectivity between the sizes of the diameters of the soils within the same site, as the highest reflectivity was for the soils with soft sizes, then the largest size, then the largest.
- When comparing the soils in the percentage of reflectivity within the same size of the different sites, the study showed that the soils of the village of Balak Qout village were higher in reflectivity compared to the rest of the sites.
- The carbonate content had a clear effect on raising the spectral reflectivity ratios in all locations with overlapping in the amount of reflected rays due to the scattering that occurs due to the surface roughness of the models with larger diameters.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

The authors declare no conflict of interest.

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