Influence of daylight changes in colour coordinates of a Munsell® Soil-Colour Chart

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ABSTRACT

CIELAB colour coordinates of the 238 chips available in the Munsell® soil-colour charts (Munsell Colour Company, 2000) have been computed from different daylights measurements in Granada (Spain). Specifically, we considered daylight for 6 days with various atmospheric conditions at 12:00 h, and 16 measurements, at different times from sunrise to sunset, for a given cloudless day on summer. At 12:00 h, even with considerably different sun elevations and atmospheric conditions, the change in CIELAB colour co-ordinates of any chip was very small. However, for some specific chips the values of CIELAB co-ordinates may change considerably along a given day in such a way that, although they are nearly constant at midday, important changes happen at sunrise and subset, both in the same sense: lightness and chroma decreases, while hue-angle increases.

1. INTRODUCTION

Colour is perhaps the most obvious feature of soils and is easily seen by laypersons. The importance of soil colour relates to the fact that such soil properties as organic matter, mineralogy, and moisture content are strongly related to soil colour[1]. In normal practice, the most widely used method for soil-colour specification is the use of standard soil-colour charts following the Munsell notation. This method is used by all soil-classification systems as an influential diagnostic criterion for identifying the taxonomic class of a soil[2], as well as in studying soil formation and evaluation.

Several recommendations have been reported for the visual colour measurement of soil using Munsell soil-colour charts[3]. Among other recommendations for an optimal soil-colour measurement, the illumination conditions should be standardized to approximate illuminant D65 (i.e. diffuse daylight). The visual appearance of the colour of soils is affected by the quality and intensity of the light. Colour determination may be inaccurate early in the morning or late in the evening. Soil scientists have observed that when the sun is low in the sky or the atmosphere is smoky, the light reaching the soil and the light reflected is redder. The reading of sample colour at these times is commonly one or more intervals of hue redder than at midday[4]. Colour also appears different in the subdued light of a cloudy day than in bright sunlight. In any case, it should also be borne in mind that in normal practice the same kind of light reaches both the soil-colour chart and the soil sample under analysis.

The numerical change in colour co-ordinates of natural and artificial objects observed under different natural-lighting conditions has been reported in the literature[5]. However, there are few numerical analyses of the colour changes in soil samples and standard Munsell soil-colour charts. For soil-colour assessment in the field, it has been suggested to avoid early-morning or late-evening light[6] (i.e. twilight conditions), but we do not know how much colour differs at other times or the soil colours that undergo the greatest change.

The goal of the current paper is to report on the change of colour co-ordinates of the chips provided by a Munsell soil-colour chart when illuminated by daylight under different solar elevations at midday on different days, and also including twilight as well as middle hours of one day[7]. These results should provide useful information for soil scientists trying to achieve a close match between soil samples and Munsell soil-colour charts in the field. Eventually, we are interested in the characteristics of this metameric (or parameric) match, as well as about a potential numerical correction in the soil colours measured at any time in order to refer them to the light of sunny midday.

2. METHOD

We have used a completely new Munsell soil-colour chart (washable edition 2000[8]). The spectrophotometric measurements were performed (just after opening the sealed package) by a Minolta CM-2600d spectrophotometer, from 360 to 740 nm at 10 nm intervals, using d/8 geometry and specular component excluded.

The different daylight spectra (hemispheric spectral irradiances, from 300 to 1100 nm at 5-nm steps) were measured by a LI-COR LI-1800 spectroradiometer over a period of two years at the University of Granada Science Faculty (37°11' N, 3°37' W, 680 m), Spain, located in an urban, non-industrial area.

We have computed the CIELAB co-ordinates for each of the 238 chips of our Munsell soil-colour chart under various daylight conditions (different days and hours). Specifically, we have considered 6 different days: 3 cloudless (8 September 1997, 10 February 1997 and 2 December 1996), 1 cloudy (7 April 1997) and 2 mixed (27 December 1996 and 10 July 1996). Measurements were taken at 12:00 h for each day and at different hours for one day. We have considered the daylight of the different days at 12:00 h, because this hour is used by soil scientists as a reference to perform the match between soil samples and Munsell chips. In addition, we have considered daylight spectra over an entire day (8 September 1997) checking the changes in CIELAB colour co-ordinates L^*, C^*_{ab} and h_{ab} of all chips in the Munsell colour chart at different hours. All tristimulus values were computed assuming CIE 1931 Standard Observer[9]. Transformations to CIELAB were performed assuming as the reference white an object with constant spectral reflectance equal to 100% illuminated by the different daylights. We have worked out the tristimulus values and CIELAB co-ordinates for all the chips of the available Munsell soil-colour chart, placing attention on changes in the co-ordinates due to the different atmospheric conditions of different days, and different sun elevation on a given day.

3. RESULTS

We have selected a cloudless day on summer (8 September 1997) with 16 measurements of irradiance between 5:48 and 18:26 GMT. Figure 1 shows the spectral irradiance of daylight measured at the hours considered. The shapes of the curves are quite similar and the main changes are in the absolute values of the irradiance. The same occurred on the other days measured.

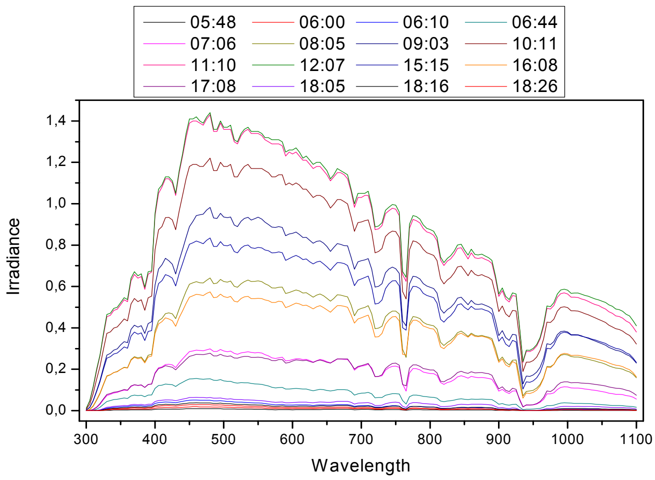

Figure 1: Spectral daylight irradiance (relative units) at 16 different hours of the day 8 September 1997, from measurements performed in Granada (Spain).

Figures 2, 3 and 4 show the highest and lowest changes, for each one of the CIELAB colour co-ordinates, among the 238 chips measured. These highest and lowest changes were found by computing the standard deviation of the values of L^*, C^*_{ab} and h_{ab} for all the chips. In the above-mentioned Figures, the left sides show changes corresponding to different days at the same hour (12:00 h), while right sides plot the changes on different hours of the same day (8 September 1997).

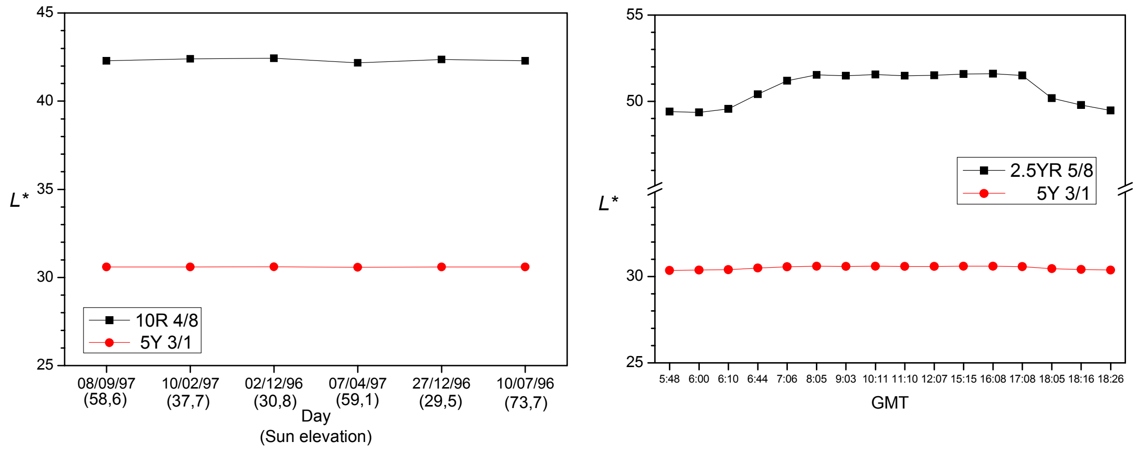

Figure 2: Maximum and minimum changes in L^* for the chips of the Munsell soil-colour chart (2000 Ed.). Left: at different days but the same hour (12:00 h). Right: at different hours for a day (8 September 1997).

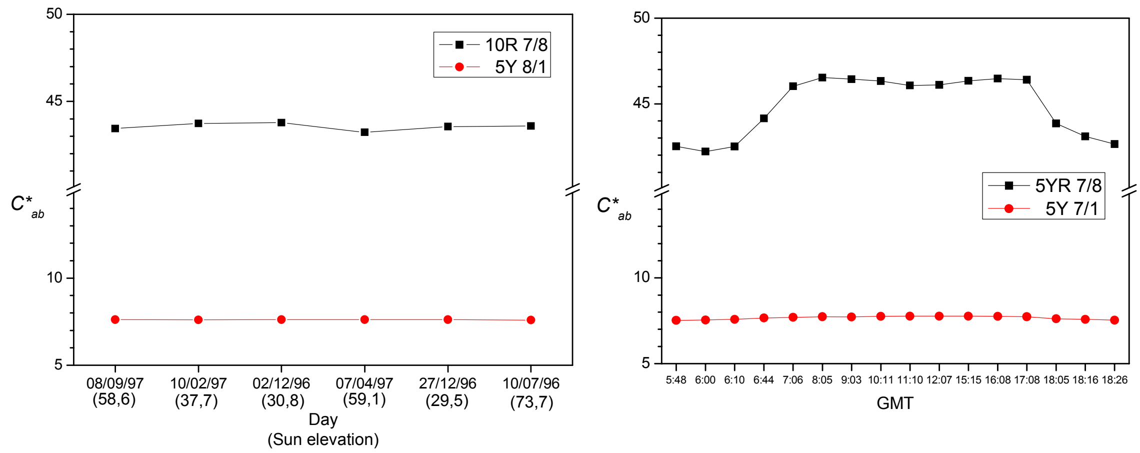

Figure 3: Maximum and minimum changes in C^*_{ab} for the chips of the Munsell soil-colour chart (2000 Ed.). Left: at different days but the same hour (12:00 h). Right: at different hours for a day (8 September 1997).

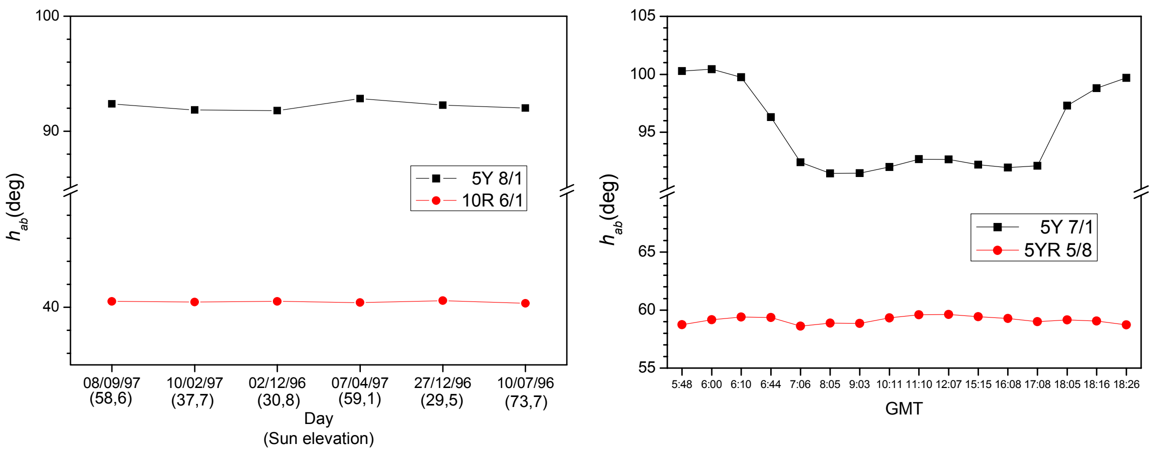

Figure 4: Maximum and minimum changes in h_{ab} for the chips of the Munsell soil-colour chart (2000 Ed.). Left: at different days but the same hour (12:00 h). Right: at different hours for a day (8 September 1997).

From Figures 2 to 4 we note that at the same hour (12:00 h), even with considerably different sun elevations, the changes in the colour co-ordinates of the chips are very small. Only a minor decrease in L^* and C^*_{ab}, as well as a minor increase in h_{ab}, can be noticed for the cloudy day (7 April 1997). On the contrary, for some specific chips the values of CIELAB colour co-ordinates changed considerably over a day. In these cases the colour co-ordinates are nearly constant at midday, the main changes happening at sunrise and sunset, both in the same sense: lightness and chroma decreased, while hue-angle increased. Before 7:00 h and after 5:00 h the colour chips turned darker, less saturated and yellowish. In the worst case, the colour of some chips changed about 10 h_{ab} degrees, 5 C^*_{ab} units, and 3 L^* units.

Figures 2 and 3 show that the highest change in L^* and C^*_{ab} occurred in chips with a pale and chromatic colour. This fact disagree with the idea that quality and intensity of incidental light is especially critical for chips of low Munsell Chroma and low Munsell Value[3]. The lowest change in L^* and C^*_{ab} were found in the chips 5Y 3/1 and 5Y 7/1 (or 5Y 8/1), respectively, all of them virtually achromatic. Figure 4 shows that parameter h_{ab} was only affected by twilight conditions in light achromatic chips, such as 5Y 7/1.

4. CONCLUSIONS AND FUTURE WORK

Daylight change at different hours of a same day may modify the colour coordinates of the chips of the Munsell soil-colour chart, particularly at twilight conditions. With respect to the recommendation of using the Munsell soil-colour charts at 12:00 h, it would be useful to make corrections for different hours. However, the colour changes of the chips attributable to different atmospheric conditions were negligible.

For a given set of representative soil samples, the characteristic of the best colour match achievable using the Munsell soil-colour charts should be studied under different daylights. Advanced CIELAB-based colour differences as well as colour-appearance models could be used for this purpose.

Acknowledgements

Ministerio de Educación y Ciencia (Spain), research projects CGL2004-02282/BTE, FIS2004-05537, and DPI2004-03734.

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