

Colour variation in standard soil-colour charts

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Abstract. This paper presents colourimetric analyses of 6 standard soil-colour charts (1372 chips) from different manufacturers, editions, and degrees of use. The CIELAB L^* , a^* , and b^* were found to have significant (analysis of variance, $P < 0.05$) variations among tested charts, and the Munsell hue, value, and chroma measured in most chips varied from their notation by as much as 1 unit. This discrepancy can be attributed to printing differences and/or colour fading. The Munsell loci of constant hue and chroma plotted in CIELAB colour space showed that colour fading is not uniform, so that visual steps between neighbouring chips change, and constant hue and chroma lines become deformed. The colour difference between chips identically designated in two charts ranged from 0.94 CIEDE2000 units (above perception threshold) for charts from the same manufacturer and degree of use, to 3.72 CIEDE2000 units for old charts from 2 different manufacturers. Chips from old charts became yellowish, darker, and less saturated. These colour changes are consistent with the responses of 10 observers who, on assessing 10 soil-colour samples, reported Munsell notations to have redder hue, lighter value and greater chroma. Periodic colourimetric checking of soil-colour charts would be advisable in order to avoid mistakes in soil-colour description.

Additional keywords: Munsell, CIELAB, CIEDE2000, visual determination, spectrophotometric measurement.

Introduction

Colour is a distinctive feature of soil. Early efforts to set soil-colour standards and terms for field use followed the tradition of naturalists, who since the 17th Century used colour charts to describe plants and animals (Pacht 1983). The first sets of standard soil-colour charts were published in the 1940s using cards arrayed in a loose-leaf notebook (Simonson 1993; Oyama and Takehara 2001). Like the current soil-colour charts, those charts consisted of artificially coloured papers (chips) mounted on constant base cards, showing chroma and lightness variations in horizontal and vertical directions, respectively, as in the Munsell system (Wysocki and Stiles 1982). Soil colours are determined by visual comparison, seeking the closest match between the soil sample and one of the standard chips in the soil-colour charts. Thus, the Munsell designation of this chip (hue, value, and chroma) is assigned to the soil sample under study.

Currently, soil colour can be measured objectively by colourimeters or spectrometers, which follow numerical specifications in colour-representation systems such as CIE x,y,Y , CIELAB, or OSA (Melville and Atkinson 1983; Torrent and Barrón 1993; Sánchez-Marañón *et al.* 2004). However, in normal practice, the most widely used method

for soil-colour specification is the use of standard soil-colour charts following the Munsell notation (Landa 2004). The colour measured in this way has far-reaching implications for field examination and description of soils (Soil Survey Staff 1993). Moreover, this method is used by all soil-classification systems as an influential diagnostic criterion for identifying the taxonomic class of a soil (FAO 1998; Soil Survey Staff 1999) as well as in studying soil formation and evaluation (Dahlgren *et al.* 1997; Brouwer and Fitzpatrick 2002; Brown *et al.* 2004).

Several problems have been described previously in relation to identifying the colour of soil specimens using standard soil-colour charts. Thus, colour determined by this technique is affected by the spectral properties and amount of light illuminating the samples, viewing angle, status of the soil sample (e.g. size, moisture content, and texture), subjectivity of the human observer, and the limited number of available chips to achieve a perfect colour match with the soil sample (Shields *et al.* 1966; Baumgardner *et al.* 1985; Sánchez-Marañón *et al.* 1995). On the other hand, the cylindrical structure of the Munsell system, which has a circular scale for hue and two different linear scales for value and chroma, makes Munsell

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