

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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Table of Contents Colour Variation In Standard Soil Colour Charts Researchgate

1. Understanding the eBook Colour Variation In Standard Soil Colour Charts Researchgate
 - The Rise of Digital Reading Colour Variation In Standard Soil Colour Charts Researchgate
 - Advantages of eBooks Over Traditional Books
2. Identifying Colour Variation In Standard Soil Colour Charts Researchgate
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Colour Variation In Standard Soil Colour Charts Researchgate
 - User-Friendly Interface
4. Exploring eBook Recommendations from Colour Variation In Standard Soil Colour Charts Researchgate
 - Personalized Recommendations
 - Colour Variation In Standard Soil Colour Charts Researchgate User Reviews and Ratings

- Colour Variation In Standard Soil Colour Charts Researchgate and Bestseller Lists
- 5. Accessing Colour Variation In Standard Soil Colour Charts Researchgate Free and Paid eBooks
 - Colour Variation In Standard Soil Colour Charts Researchgate Public Domain eBooks
 - Colour Variation In Standard Soil Colour Charts Researchgate eBook Subscription Services
 - Colour Variation In Standard Soil Colour Charts Researchgate Budget-Friendly Options
- 6. Navigating Colour Variation In Standard Soil Colour Charts Researchgate eBook Formats
 - ePub, PDF, MOBI, and More
 - Colour Variation In Standard Soil Colour Charts Researchgate Compatibility with Devices
 - Colour Variation In Standard Soil Colour Charts Researchgate Enhanced eBook Features
- 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Colour Variation In Standard Soil Colour Charts Researchgate
 - Highlighting and Note-Taking Colour Variation In Standard Soil Colour Charts Researchgate
 - Interactive Elements Colour Variation In Standard Soil Colour Charts Researchgate
- 8. Staying Engaged with Colour Variation In Standard Soil Colour Charts Researchgate
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Colour Variation In Standard Soil Colour Charts Researchgate
- 9. Balancing eBooks and Physical Books Colour Variation In Standard Soil Colour Charts Researchgate
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Colour Variation In Standard Soil Colour Charts Researchgate
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Colour Variation In Standard Soil Colour Charts Researchgate
 - Setting Reading Goals Colour Variation In Standard Soil Colour Charts Researchgate
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Colour Variation In Standard Soil Colour Charts Researchgate
 - Fact-Checking eBook Content of Colour Variation In Standard Soil Colour Charts Researchgate
 - Distinguishing Credible Sources

13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
14. Embracing eBook Trends
 - Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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