Deviation in soil colour determination based upon students visual perception

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Abstract
The determination of soil colours is essential not only in soil science research but on other areas (e.g. forestry), too. Twenty samples were collected from various parts of Hungary and air dried. 110 bachelor students were chosen to identify the soil colours. They used the Munsell Soil Colour Charts. The twenty samples were identified in dry and in wet conditions. Statistical analyses were done by the SPSS program. Groups were made of the basic data to compare the recognition of colours. X^2 probe was used to tell if there were any differences between the males and females, and Kruskal-Wallis test with Dunn's post hoc test to tell the difference between dry and wet soils' value and chroma values. Males and females recognized the wet and dry values of the examined soils approximately at or around the same spots, however the differences grew during the recognition of wet values, but it was not significant. The Kruskal-Wallis test with Dunn's post hoc test showed that in most of the cases there were 5 or 7 similar groups of soil colours in the 20 examined samples. It is visible that soils No. 4, 10, 14 and 17 have different colours. It was proven by the analyses, too. We can state that the difference of lighter colours from darker colours can be proven with analysing the Dry Value. Soil No. 16 had the most (9) similar pairs during the analyses of the Dry Values. The analyses of the Dry Chroma and the Wet Value of the samples proved soils No. 10, No. 14 and No. 17 to have the lowest number (3-4) of similar pairs, so they are proved to be different from other samples.

Key Words
No more than six key word items in order of decreasing relevance.

Introduction
The determination of soil colours is essential not only in soil science researches but on other areas (e.g. forestry), too. Wills *et al.* (2007) evaluated soil colour measurements to predict soil organic carbon (SOC) for agriculture and prairie land uses. In soil science one of the most widely used methods to classify soil colours is using the Munsell® Soil Colour Chart.

A cross-plot of Munsell values and their SOC concentrations revealed characteristic, non-overlapping areas for each particle-size class and the bulk soils. Clay-size separates and bulk soils were almost identical in Munsell values, although for clay-size separates SOC concentrations were much larger than for bulk soils (Wiesenberg *et al.* 2006).

The type of colour model to use will depend on the purpose. If soil colour is being used for merely descriptive purposes, then the Munsell HVC system will remain appropriate. If it is being used for numerical statistical or predictive analysis, then colour models that use Cartesian-type coordinate systems will be more useful (Rossel *et al.* 2006).

Munsell colour identification system was used for various other purposes, not only for soil colour classification. Pross *et al.* (2007) determined the colours of six sporomorph groups from geological drillings using Munsell colour standards under reproducible optical conditions. Hytonen and Wall (2006) used colours to find the correlations between colour attributes and foliar nutrient. Concentrations were at their highest when colour was measured from the tips of fresh needles. Singh *et al.* (2006) used remotely sensed data to determine soil degradation processes by soil colours, using the Munsell Colour System.

There were numerous attempts to make soil colour recognition more proper. Benavente *et al.* (2006) used a data set of 387 colour reflectance for scoring method to collect a set of judgments adequate for the fuzzy modelling of a colour-naming task. Laamanen *et al.* (2006) presented a novel general transformation between reflectance spectra and the corresponding coordinates of the Munsell Colour System. Romney and Fulton (2006) present a method for transforming reflectance spectra into Munsell colour space by using hypothetical absorbance curves based on Gaussian approximations of the prime colours and a simplified version of opponent process theory.

Several authors investigated some special parts of the Munsell Soil Colour Chart, e.g. Pridmore (2007) had experiments with effects of purity on hue in various conditions; Thulasidas *et al.* (2006) had experiments with hue and chroma.

Cheung and Westland (2006) described methods to select optimum colour samples from a set of 1269 Munsell surface colours. The work proves that it is possible to select 24 samples from the Munsell set that outperform the GretagMacbeth ColourChecker and that this selection can be efficiently derived using an algorithm called MAXMINC.

Lehtonen *et al.* (2006) explain a method for calculating the optimal sampling interval of colour spectra (1269 samples were used). It is shown that a 20 nm interval is enough for the smooth Munsell set alone, but 10 nm is not enough for the same set matched with a fluorescent light source. 5 nm was enough in most situations. Matz and Figuero (2006) introduced a nonlinear local contrast enhancement method. This method utilizes the Munsell value scale which is based upon human visual perception. Use of the Munsell value scale allows for the partitioning of the grey scale into ten discrete subintervals.

Our aim was to find out if there were any identifiable group of soils statistically and if there were any difference between the recognition of hue, chroma and value of the 20 examined soils with the 110 students.

Methods

Twenty samples (from topsoil, B horizon and parent material) were collected and air dried from various part of Hungary to give a good range of the Hungarian soils. 110 bachelor students (age 18-20) were chosen to identify the soil colours. They used the Munsell Soil Colour Charts under the same lighting conditions. The twenty samples were identified in dry and wet conditions, too. Statistical analyses were done by the SPSS program. Groups were made of the basic data to compare the recognition of colours by males and females. X^2 probe was used to tell if there were any differences between the males and females, and Kruskal-Wallis test with Dunn's post hoc test to tell the difference between dry and wet soils' value and chroma values.

Results

Results with F probe

The first approximation of analysing the differences between the colours was the calculation of the standard deviation and the F probe. In case of Soil No. 1 the F probe of the values resulted <0.01, while the chromas resulted 0.9<, so the identification of the values and the chromas of this colour has to be investigated furthermore. It is the opposite with Soil No. 2, where both F probes of values and chromas resulted high F probe values (0.85<). There were extremities in case of the chroma of Soil No. 4 (7.67E-07) and No. 10 (8.26E-14); and No. 12 (2.17E-06). There were extreme differences between recognition of the following values and chromas: No. 1, No. 3, No. 4, No. 6, No. 7, No. 10, No. 13.

Results with X2 probe

Males and females recognized the wet and dry values of the examined soils approximately at or around the same chips; however the differences grew with finding the wet values (not significant). There are no differences between the recognition of dry and wet samples in case of females but there is in case of males. It is visible that the difference is caused by the recognition of the colours in the hues of 10YR and 2,5Y. The biggest difference was in case of 2,5Y. Male participants overuse 2,5Y during the recognition of dry samples and underused in case of the wet samples compared to the average of distribution of the samples.

Kruskal-Wallis test with Dunn's post hoc test

In most of the cases there were 5 or 7 similar soils in the 20 examined samples (Figure 1-4.). No. 4, 10, 14 and 17 are different from the other samples, No. 14 and No. 17 is reddish, No. 4. and No. 10 is whiter than the others. It is proven by the analyses, too.

Wet Chroma

The following examined soils belong to the same group (Figure 1a.):

- Wet Chroma Group 1: 1, 2, 7, 8, 9, 10, 11, 12 and 13;
- Wet Chroma Group 2: 5, 15, 16 and 20.

No. 14 is almost different from all the other soils. No. 17, 18 and 19 is a third group.

Wet Value

The following examined soils belong to the same group (Figure 1b.):

- Wet Value Group 1: 1, 7, 8, 9, 10, 11, 12, 13;
- Wet Value Group 2: 3, 4, 6, 16, 17, 18, 19, 20.

No. 10. and No. 14. have only 3 similar soils, No. 17. has only 4 similar soil in the dataset.

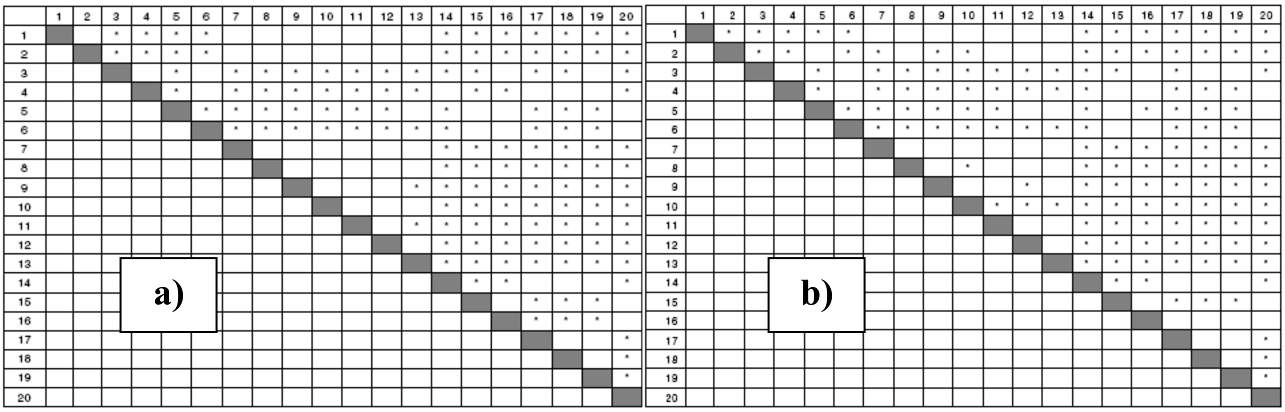

Figure 1a, b. Results of Kruskal-Wallis test with Dunn's post hoc test for a) Wet Chroma (*p<0,001, KW=1637, df=19) and b) Wet Value (*p<0,001, KW=1563, df=19)

Dry Chroma

The following examined soils belong to the same group (Figure 2a.):

- Dry Chroma Group 1: 1, 7, 8, 9, 10, 11, 12, 13;
- Dry Chroma Group 2: 4, 5, 6, 15, 16, 20.

In this case we find the same case with the lowest number of similar colours like in case of the Wet Value: “No. 10. and No. 14. have only 3 similar soils, No. 17. has only 4 similar soil in the dataset.”

Dry Value

The following examined soils belong to the same group (Figure 2b.):

- Dry Value Group 1: 1, 2, 8, 9, 11, 12
- Dry Value Group 2: 3, 6, 7, 14, 15, 16, 17; and
- Dry Value Group 3: 13, 16, 18, 19, 21.

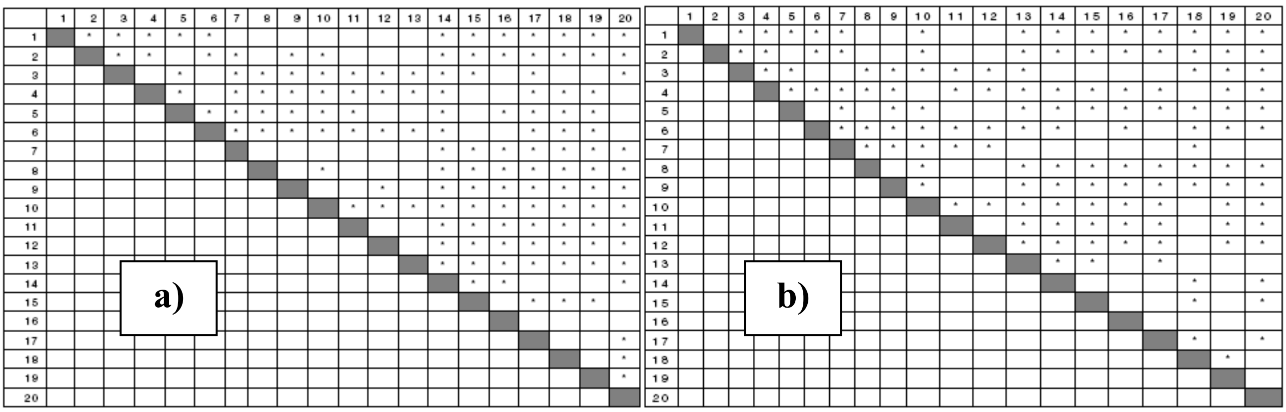

Figure 2a, b. Results of Kruskal-Wallis test with Dunn's post hoc test for a) for Dry Chroma (*p<0,001, KW=1711, df=19) and b) Dry Value (*p<0,001, KW=1736, df=19)

Dry values result the lowest number of pairs in the overall investigation. In this case soil No. 4. and No. 10. have only 2 similar soils.

Conclusion

We can state that the difference of lighter colours from darker colours can be proven with analysing the Dry Value. It is the same case with the highest similarity: soil No. 16. had the most, 9 similar pairs during the analyses of the Dry Values. The analyses of the Dry Chroma and the Wet Value of the samples proved soils No. 10, No. 14 and No. 17 to have the lowest number (3-4) of similar pairs, so they are proved to be different from other samples. Finally we can say that Wet Chroma did not prove the former statements about soils No. 4, No. 10, No. 14 and No. 17. Finally we can state that more experiments are needed in order to reach better results with soil colour identification since it is widely used in soil science as a limit of certain qualifiers in soil classification, and in other areas of everyday life, e.g. forestry, mining etc. More proper results can help to better understand soil degradation processes, to set limits of colour based separation of different diagnostic horizons in soil classification and to find the reason of coloration of the leaves in forestry.

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