Ecological Characterization of the green areas in Sopron by Plant Chemical Analysis and Hyperspectral Recording

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Abstract – Urban environmental conditions significantly affect the quality of life. The environmental impacts and their results coming from the operation of the settlement can be characterized by the measurement of the environmental components. The chlorophyll content of photosynthetically absorbed radiation, the canopy water content and soil nitrogen content are important parameters which affect the land ecosystem primary productivity and plant health. The decrease of chlorophyll content can be regarded as a useful biomarker for detection of gaseous pollutants. Our objectives included the ecological characterization of the green areas in Sopron by the examination of chlorophyll content distribution of the leaves, the establishment of correlations between the chlorophyll content and the quality and quantity of air pollutants and the validation of the row chlorophyll values come from hyperspectral images by the results of the laboratory examinations.
Leaf samples were collected at the same time of hyperspectral recording on 26th of August 2011 from five places where five samples were collected each sites. After the sample preparation and extraction the coloring matters were separated by thin layer chromatography and the quantity of chlorophyll a and b were determined. Narrow bands spectral indexes were applied to evaluate of chlorophyll contents of leaves samples.

Keywords: chlorophyll / leaves / thin layer chromatography / urban environment / hyperspectral

1. INTRODUCTION

Pigments are functionally important molecules in photosynthetic organisms. They not only harvest the light energy necessary for carbon reduction but some serve to protect the organism from excess light. The balance of photosynthetic pigments is dynamic and contributes to the maintenance of photostasis within the cell (HUNER at al. 1998). The primary light-harvesting pigments are chlorophylls a and b. Chlorophyll a is situated in the light-harvesting complexes (LHC), the core antennae as well as the reaction centers, whereas chlorophyll b is only found in the LHCs. In the blue and red spectral ranges, specific absorption coefficients of pigments are very high and the depth of light penetration into the leaf is very low (MERZLYAK and GITELSON 1995). An important characteristic of chlorophyll to keep in mind during their extraction is their sensitivity to light, heat, oxygen, and chemical degradation (GROSS 1987). These conditions should be avoided throughout sample preparation to prevent the possible formation of artifacts and to prevent their degradation. The chlorophyll content of photosynthetically absorbed radiation, the canopy water content and soil nitrogen content are important parameters which affect the land ecosystem primary productivity and plant health. Furthermore, leaf chlorophyll content is related to plant stress and senescence (MERZLYAK

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and GITELSON 1995). The decrease of chlorophyll content can be regarded as a useful biomarker for detection of gaseous pollutants. The active oxyradicals generated by CO_2, NO_2 and O_3 react with cell membrane and the membrane molecules resulting the decrease of its amount (SASAKI et al. 1983). Accurate quantitative estimates of biochemical properties of vegetation canopies are important applications of remote sensing for terrestrial ecology (GAO B. C. and GOETZ, 1995). Band–ratio indexes are commonly used techniques for estimating vegetation leaf and canopy properties, including pigment concentration (BLACKBURN 1998).

2. EXPERIMENTAL

2.1 Leaf samples Leaf samples were collected at the same time of hyperspectral recording on 26th of August 2011 from 5 places in Sopron. The following five place were selected: Széchenyi Square, Deák Square, Elisabeth Garden, Lippai School of Horticulture and Lőver Camping. On each places were layed out five shrub or tree, and three leaf samples were taken from each plant. The *Table 1-5* show the name of the species at the different monitoring points.

Table 1. The name of the species from the Széchenyi Square.

Sampling place	*Mark*	*Name of the species*
Széchenyi Square	S1-S2	Norway Maple (*Acer platanoides* L.)
	S3-S4	Border Forsytia (*Forsythia* × *intermedia* ZABEL)
	S5	Common Dogwood (*Cornus sanguinea* L.)

Table 2. The name of the species from the Deák Square.

Sampling place	*Mark*	*Name of the species*
Deák Square	D1	Common Dogwood (*Cornus sanguinea* L.)
	D2	Common Walnut (*Juglans regia* L.)
	D3	Sweet Mock Orange (*Philadelphus coronaria* L.)
	D4	European Ash (*Fraxinus excelsior* L.)
	D5	Field Maple (*Acer campestre* L.)

Table 3. The name of the species from the Elisabeth Garden.

Sampling place	*Mark*	*Name of the species*
Elisabeth Garden	E1	Deutzia (*Deutzia* × *magnifica* (LEM.) REHDER)
	E2	Tulip tree (*Liriodendron tulipifera* L.)
	E3	(Black) Jetbead (*Rhodotypos scandens* (THUNB.) MAKINO)
	E4	Mock Orange (*Philadelphus* × *virginalis* REHDER)
	E5	Sweet Gum (*Liquidambar styraciflua* L.)

Table 4. The name of the species from the Lippai School of Horticulture.

Sampling place	*Mark*	*Name of the species*
Lippai Scool of Horticulture	L1	Cherry Laurel (*Prunus laurocerasus* L.)
	L2	Sweet Mock Orange (*Philadelphus coronaria* L.)
	L3-L4	Dwarf Elderberry (Dane Weed) (*Sambucus ebulus* L.)
	L5	Silver Lime (*Tilia tomentosa* MOENCH.)

Table 5. The name of the species from the Camping.

Sampling place	*Mark*	*Name of the species*
Lőver Camping	K1-K3	Field Maple (*Acer campestre* L.)
	K4	Common Walnut (*Juglans regia* L.)
	K5	Bird Cherry (*Cerasus avium* L.)

2.2 Materials and methodes

Chemicals All applied chemicals were of analytical grade, and were purchased from Reanal (Budapest, Hungary), Sigma (Deisenhofen, Germany) and Merck (Darmstadt, Germany).

Equipment Scanning Spectrophotometer, CAMAG TLC Scanner 3 Densitometer operating with winCATS software, TLC tank, FieldSpec 3 JR spectroradiometer, GPS

Thin-Layer Chromatography (TLC) Solvent Preparation

Mobile phase Solution was prepared of 100 ml petroleum ether, 11 ml isopropanol, 5 drops of distilled water.

Extraction of the leaf pigments Using a pestle fresh leaves were grinded in a mortar with quartz sand, until it becomes a fine, light green powder. 0,030 g solid was homogenized with 80% aqueous acetone in an Eppendorf tube. Samples were extracted for 15 minutes by sonication (Elma T570), and then centrifuged for 30 minutes (1800/min).

Analysis

Chlorophyll. The supernatant was analysed on TLC silica gel. Quantitative evaluation of CAMAG TLC Scanner 3 Densitometer operating with winCATS software, in absorption mode.

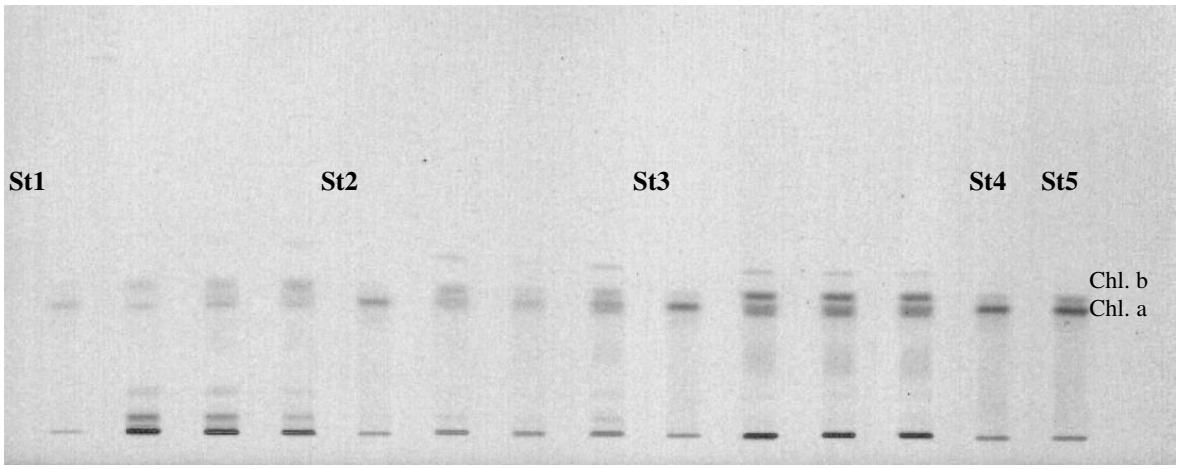

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Figure 1. The TLC seperation of the chlorophylles extracted from the leave samples.(Chl.a: chlorophyll a, Chl. b: chlorophyll b ; St1, St2, St3, St4, St5: standard tracks)

Using thin layer chromatography (TLC) two pigments could be separated from the leaf samples: chlorophyll a and chlorophyll b (*Figure. 1*).

Spectroradiometer measurement

The FieldSpec 3 JR spectroradiometer *(Analytical Spectral Devices, Boulder, CO, USA)* measures a spectrum from 350-2500 nm, with spectral resolution is 3 nm in the visible (VNIR) and 10 nm in the short wave infrared (SWIR) region. The sampling interval of 1.4 nm in the VIS and 2 nm in the short wave SWIR is interpolated to a finer sampling interval of 1 nm for a total of 2150 contiguous channels. ASD was assembled with a leaf clip system which had a halogen light source can be collect spectra of live vegetation.

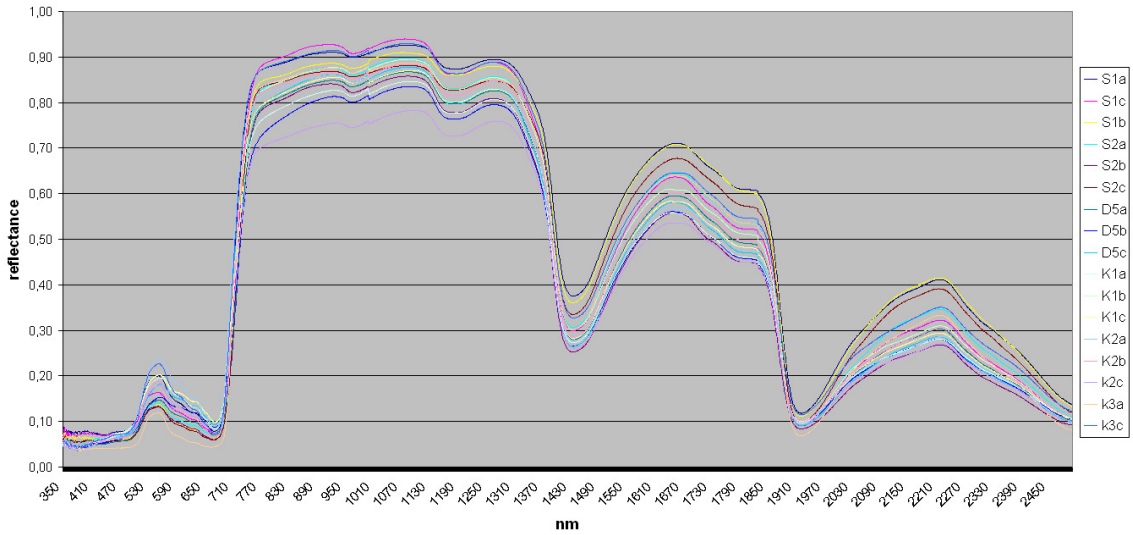

Figure 2. Reflectance spectrums of leaf samples of Acer sp.

Leaf samples were collected on five study area at the same time of hyperspectral aquisition on 26th of August 2011. Five samples were taken from each sampling place. Spectrophotometric analysis were taken immediately after ASD hyperspectral spectrophotometer measurments. After the sample preparation and extraction the colouring matters were separated by thin layer chromatography and the quantity of chlorophyll a and b were determined. The airborne hyperspectral imagery (AISA Eagle) was used in the range of 400-1000nm due to this study focuses in visible and near infrared (VNIR) spectral range.

3. RESULTS

Correlation analysis was processed to determine the strength of relationships between chlorophyll content (total chlorophyll, chlorophyll a and b) and spectral indices (NDVI, PRI DV1) and spectral wavebands (400-1000nm). Calculation with wavebands itself didn't produce significant correlation with chlorophyll contents. Spectral indices were insensitive for some other properties of leaf, than using of wavebands itself, to evaluate chlorophyll concentration. First derivate was calculated from spectral signal in order to derive red-edge position of leaves. The advantage of derivative spectroscopy is that it is relatively insensitive to variations in illumination intensity and some background properties.

Using each leaves samples didn't produce significant ($P<0.05$) correlation coefficient between chlorophyll content and spectral indexes. Hereafter, sample leaves were analysed in species groups. First derivate values (DV2) was shown to be a good predictor ($R^2=0.6288$, $P<0.05$) of *Chl b* of leaves (*Acer sp.*).

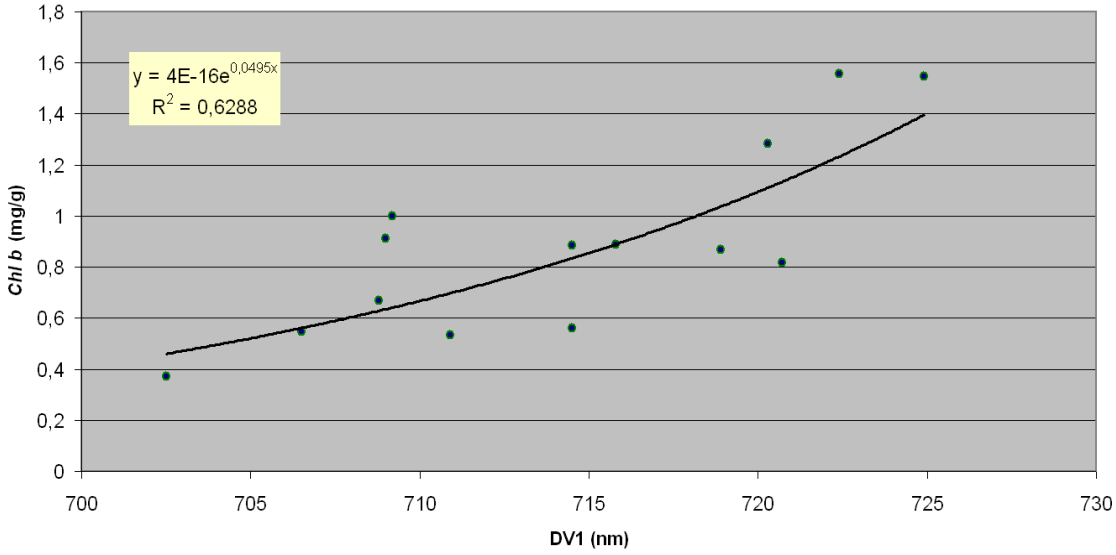

Figure 2. Scatter plot indicates the relationship between second derivate reflectance values (DV1) of Red Edge Position (REP) and Chlorophyll b (mg/g) contents

4. CONCLUSIONS

Hyperspectral field measurements and TLC analysis were applied on leaf samples in order to characterise different types of tree species of urban environment. TLC dataset was applied to quantify ASD hyperspectral spectroscopy. Narrow bands spectral indexes were used to evaluate of chlorophyll contents of leaves samples. Hyperspectral field spectrophotometer (ASD) makes it possible to quickly and non-destructively in situ measurement of the chlorophyll content in leaves. Preliminary results of field measurement produce background dataset for image processing of airborne hyperspectral images. Narrow bands indexes which were calculated based on TLC analysis and ASD measurements can be extend for all hyperspectral images in order to map of biophysical parameters of leaves in the urban area.

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