Study on some components of urban forest ecosystems with respect to recreation

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Abstract
Studies were carried out on the components of ecosystems in the region of the north-eastern parts of Lyulin Mountain in the green zone of Sofia-Pernik agglomeration (Bulgaria). Three plots in the most visited areas were investigated. Soil morphology, mechanical composition, water regime, humus substances, soil acidity and CEC of *Cambisols* were studied. The presence of exchangeable Al in surface soil layers which have formed by the suspected destruction and dissolution of layer silicate minerals. The high content of “aggressive” fulvic acids confirmed that the upper organic soil horizons are more vulnerable to stronger pollution. The concentrations of Cu and Pb were higher compared with other relatively non-polluted territories nearby, while other pollutants Zn, Cd and Pb were in lower concentrations. The natural regeneration in *Fagus sylvatica* L. pure or mixed forests was observed. The bio-groups have good structure with beech as a dominant tree species. The results showed an influence of urban pollution on forest vegetation. The Factor of Accumulation (FA) was estimated for the main tree species and the trees were arranged according to their preferences to element’ accumulation.

Key Words
Parks, cambisol soil types, vegetation, anthropogenic effects.

Introduction
Recreation areas have a long-term effect on soils and total ecosystems and studies in these zones are of a great importance. The “compaction” effect is a direct result of recreation areas and could be expressed in: a) direct mechanical changes in soils and b) damages in physical and chemical soil properties in the upper soil horizons (Brown *et al.* 1977). The level of soil compaction is related to decreases in soil moisture in surface horizons and the low percent of porosity, which promotes poor physical properties and changes textural fraction ratio. The level of compaction is also related to the decrease in exchangeable Ca and Mg and in other cases Al. Moreover, recreation areas are also influenced by understory vegetation and the processes of natural regeneration, which is related to the development of poor productivity in surface soil horizons (Stoyanova and Grozeva 1995). The aim of this study was to investigate both soil characteristics and natural regeneration in urban forest ecosystems in proximity to Sofia region with respect to recreation areas.

Materials and methods
We have analyzed the components of ecosystems in the region of the north-eastern parts of Lyulin Mountain, situated in the green zone of Sofia-Pernik agglomeration (Bulgaria). The experiment was performed between 1996 and 1998. The characteristics of the chosen three experimental plots are presented in Table 1. Morphological characteristics were described at the macromorphological level, which includes parameters such as colour and structure. This information established soil types to be *Cambisols* (FAO 1998; Table 1).

Table 1. Soil characteristics of the plots.

Plot	*Cambisols* (FAO,1998)	Dominant tree species	Origin, age	Exposition; part of the slope; slope	Altitude (m)
Manastira	*Eutric Cambisols*	*Fagus sylvatica* L.	Natural, 100 years	E; central part of the slope; 15-18°	850
Hizhata	*Eutric Cambisols*	*Fagus sylvatica* L.	Natural, 40 years	E; low part of the slope; 10-12°	920
Poljanite	*Modic Cambisols*	Herbaceous; single trees of *Fagus sylvatica* (and other tree species)	Natural, 30-60 years	Upper part of the slope; 3°	940

The soil morphology, mechanical composition, water regime, humus substances, soil acidity, CEC and heavy metals content of soils were characterized. Natural regeneration was measured by application of dendro-biometrical studies and the impact of recreation areas was determined using the database from national statistics annuals.

The sampling of soils was completed for one representative soil profile per plot and the following characteristics were determined according to standardized methods (Donov *et al.* 1974): *Bulk density* – method of Katchinski; *Texture* – pipette method with HCl; *Soil acidity* – in distilled water - with pH-meter "Pracitronic, MV 88"; *Soil organic matter (SOM)* [%] – ISO 10694; *Total nitrogen* [%] – Kjeldhal; *Exchangeable K* – method UNEP – UN / EC 910651 by AAS Perkin Elmer 370 A; *Heavy metals* - AAS Perkin Elmer 370 A and *CEC* – Ganev and Arsova method (Ganev and Arsova 1980). The Factor of Accumulation (FA) was estimated as a ratio between the content of the element in the leaves a.d.m. (mg/kg) and the content of the element in the rooting zone (mg/kg).

Results and discussions

From Figure 1, which presents the average soil moisture regime, we established that the dry period is during August and the water deficiency is higher in open plot (i.e. Poljanite).

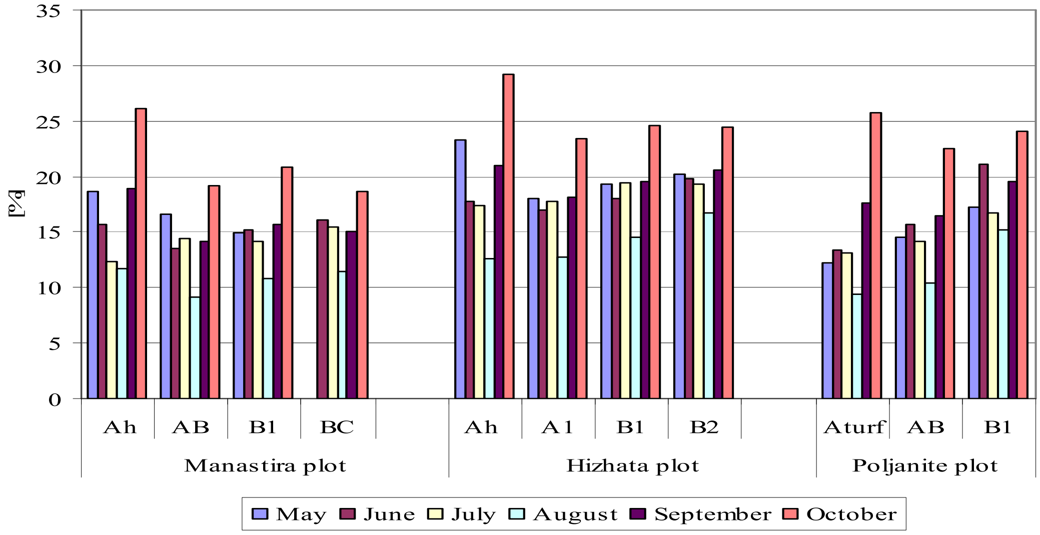

Figure 1. Soil moisture seasonal dynamic in studied experimental plots estimated with mean values.

Table 2. Physical characteristics of *Cambisols* from Lyulin Mountain.

Object,depth (cm)	Bulk density (g/cm^3)	Texture fractions (%) clay	sand	<0.001 mm	Porosity (%)	Relative density	Hygroscopic moisture (%)	Moisture of permanent fade (%)
				Manastira plot				
Ah 0-6	0.96	41.02	58.98	5.33	58	2.28	2.51	4.36
AB 6-24	1.05	49.08	50.92	10.63	57	2.46	2.19	3.93
B_1 24-63	1.17	73.99	26.01	10.89	53	2.49	2.75	4.80
BC 63-80	-	16.46	83.54	2.06	-	2.45	2.84	5.41
				Hizhata plot				
Ah 0-4	1.10	70.25	29.75	4.85	54	2.40	3.26	5.98
A_1 4-19	1.06	45.31	54.69	8.55	64	2.43	2.97	5.52
B_1 19-47	1.34	54.17	45.83	2.92	46	2.47	4.18	7.96
B_2 47-80	1.39	12.40	87.60	1.03	42	2.38	3.30	7.02
				Poljanite plot				
A_{turf} 0-12	1.08	33.51	66.49	4.71	56	2.48	4.73	7.62
AB 12-29	0.97	49.64	50.36	7.03	58	2.33	3.41	6.22
B_1 29-70	1.14	16.46	83.54	2.16	55	2.51	2.90	6.50

The brown forest soils in the region are strongly influenced by the products of both broadleaved vegetation and other factors of soil formation. Results obtained for soil physical characteristics of studied plots are presented in Table 2 and show the bulk density varied from 0.96 to 1.39, which is a prerequisite for good soil aeration. The relative density varies around 2.5 and the ratio between organic and mineral parts of the soils is also good. The porosity stays near to 50 % in the different soil horizons. The textural composition the soils are sandy loams (SL). Only in the first experimental plot – Manastira – was there sufficient clay accumulation in the B-horizon and this could be explained with leaching at plot level.
The results of chemical analysis of some soil characteristics are presented (Table 3).

Table 3. Chemical characteristics of soils from the studied experimental plots.

Plot/horizon	SOM (%)	Total N (%)	pH (H_2O)	CEC (meq/100g)	Exchangeable ions (meq/100g)			Heavy metals (mg/1000g)					
					Al	Ca	Mg	Mn	Fe	Cu	Zn	Pb	Cd
Manastira plot													
Ah	5.4	0.15	5.3	30.1	0.3	19.1	3.5	115	1665	5.7	14.2	3.9	-
AB	3.44	0.09	5.3	24.9	0.6	8.1	11.8	105	1662	5.9	19.8	4.3	-
B_1	0.64	0.07	5.4	32.9	0.2	21.6	7.5	90	1687	9.9	13.6	2.2	-
BC	-	0.06	5.5	37.5	0.3	21.6	10.8	98	1687	9.3	11.4	1.6	0.2
Hizhata plot													
Ah	9.67	0.15	4.9	40.2	3.1	23.2	4.1	88	1687	9.5	9.8	2.3	0.2
A_1	3.87	0.11	4.9	40.8	3.4	19.3	7.9	108	1707	9.8	11.4	2.3	0.2
B_1	1.46	0.07	6.1	50.9	0.0	25.2	17.9	135	1740	13.2	17.1	0.1	0.2
B_2	-	0.06	6.7	51.4	0.0	26.0	17.6	110	1742	14.5	19.1	1.	0.2
Poljanite plot													
A_{turf}	4.49	0.11	6.1	51.4	0.0	41.3	2.2	125	1725	14.3	11.1	1.6	-
AB	3.44	0.18	6.0	44.1	0.0	29.2	7.8	130	1697	9.8	18.2	2.4	-
B_1	2.83	0.12	5.7	41.1	0.2	23.8	11.5	125	1685	10.3	18.4	1.8	-

The SOM is higher in the plots with good developed forest vegetation (Manastira and Hizhata plots). The profile distribution of soil organic substances is different for forests plots and the open plot. In the Poljanite plot the decrease in SOM in depth is relative uniformity. Soil nitrogen concentration is between 0.06 and 0.18 % and the trends in soil profiles are similar to carbon contents. Available nitrogen content depends on soil acidity. In the studied soils the pH is acid in the upper soil horizons of forested areas and low acidity in the open plot and as a whole these soils have poor nitrogen regimes. Results show the presence of intense ions-exchangeable processes in soils – CEC is between 25 and 50 meq/100g. The exchangeable Al only exists in surface layers of the Hizhata plot where acidic conditions may lead to layer silicate destruction and an increase in relatively low levels of exchangeable Al concentration. According to colloidal reactivity these soils could be ordered as follows: Manastira plot – mean colloidal, Poljanite plot – strong colloidal and Hizhata plots- very strong colloidal. According to the data the surface soil horizons are vulnerable to stronger pollution and other negative anthropogenic influences. The heavy metal content confirms this assertion. The soils from Manastira plot with pH = 5.3 are endangered by the accumulation of Zn and Pb. This is also observed in soils from the Poljanite plot where the pH = 5.7 and there is a potential danger from Cu and Zn pollution. The probability of heavy metal pollution is low in the Hizhata plot by reason of higher pH values (6.1 and 6.7 for deeper soil horizons respectively). Comparative analyses with the database from relatively non-polluted regions nearby show that the content of Cu and Pb is higher in Lyulin Mountain.
The other part of our studies was related to processes associated with the natural regeneration in the recreation areas. The natural regeneration of forests of *Fagus sylvatica* L. was also determined. The observations showed that the bio-groups have good structure with beech-tree as dominant species (Figure 2).

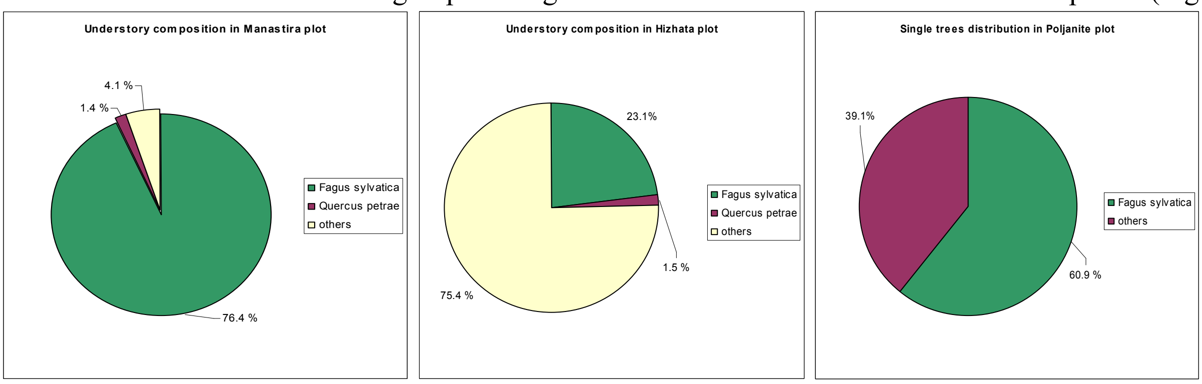

Figure 2. Natural regeneration in bio-groups of experimental plots.

The chemical analyses of the assimilation organs of trees present the influence of urban pollution on forest vegetation. The Factor of accumulation (FA) was estimated for the main tree species and trees were arranged according to their preferences to element' accumulation as follows: *Fagus sylvatica* L.: Mn > Zn > Cu > Pb > Fe; *Quercus petrae* Liebl. : Mn > Zn > Pb > Cu > Fe; *Acer pseudoplatanus* L.: Zn > Pb > Cu > Mn > Fe; *Tilia cordata* Mill.: Pb > Zn > Cu > Mn > Fe; *Acer platanoides* L.: Zn > Mn > Pb > Cu > Fe; *Crataegus monogyna* Jacq.: Zn > Pb > Cu > Mn > Fe.

Concentrations of heavy metals in assimilation organs of trees are not an immediate threat both to the vegetation and to those who use this park of the green system of the capital city as a place for recreation. The status of forest ecosystems in Lyulin Mountain is good and ensures appropriate conditions for short and durable recreation.

Conclusion

The direct impact from recreation activities was established in the Hizhata plot where in surface soil horizons the bulk density is higher and there is an increased presence of exchangeable Al. The surface soil horizons in studied plots are susceptible to increased soil pollution. Soils with low pH values are endangered by heavy metal pollution, especially from Zn and Pb. The process of natural regeneration is good and this contributes the development of improved recreation areas. The biometrical analyses show that the bio-groups have good structure with diversity of tree species in good health. As a whole the beech-trees dominates in the understory vegetation. The increase in heavy metals content in tree leaves confirms the sanitary and esthetic functions of the forests and the necessity to instigate prevention measures and monitoring of forest ecosystems in recreation zones. At present the status of forest ecosystems in Lyulin Mountain ensures appropriate conditions for short and durable recreation.

References

Brown JH JR, Kallsz SP, Wright WR (1977) Effects of recreational use on forested sites. *Environmental management* **1**, No.5, 425-431.

Donov V, Gentcheva S, Yorova K (1974) 'Guidance for exercises in forest soil science' (Zemizdat Publishing: Sofia).

FAO (1998) World Reference Base of Soil Resources, by ISSS-ISRIC-FAO. World Soil Resources Report No.84. (FAO: Rome).

Ganev S, Arsova A (1980) Methods for determination of strong-acid and slight-acid cation exchange in soil. *Soil Science and Agrochemistry* **15**, No. 3, 22-33.

Stoyanova M, Grozeva M (1995) Status of ecosystems loaded by recreation in Lyulin Mountain. In 'Problems of regional development of Bulgaria' pp. 27-29. (Sofia University Publishing).