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CITY PARKS IN EUROPE

Abstract: The goal of this paper is to present European parks form the point of view of their natural environment and ecological functions which they fulfill in the city. Parks situated in valley landscapes have been used as the object of study, since these types of parks predominate in Europe. These are: Hyde Park in London, Clara Zetkin Park in Leipzig, Tiergarten in Berlin and Łazienki in Warsaw.

Key words: city park, ecological functions, Łazienki Park, Hyde Park, Clara Zetkin Park, Tiergarten, valley.

In most cities of Europe green areas, including parks and gardens, are concentrated predominantly in river valleys and other land depressions. Analysis of historical maps shows that such layout persists despite of intensive urban development. Natural conditions in valleys, not conducive to urban development, are the main cause of such distribution. These conditions are particularly unfavourable at the bottom of valleys and on low over-flood terraces, due to a large thickness of weak load bearing surface and shallow ground water. Additionally, the situation is made worse by the bioclimatic conditions, such as high humidity as well as air flow and stagnation (Stala 1978). Zoological gardens, aviaries and gardens created on such waterlogged areas were originally designed for recreation and leisure pursuits of royalty and aristocrats. Gradually, they became recreation areas for the whole population. Nowadays, when living conditions in cities deteriorate, among other things due to air pollution or to the increase of concrete covered areas, it is expected that parks will fulfil not only recreational, but also an ecological function. The **goal** of this paper is the study description of the natural environment in parks situated in river valleys, as well as identification of its ecological functions. For this purpose, a comparative analysis of materials dealing with the natural environment of parks has been conducted, completed by the author's own research.

For this research, a few European parks located in river valleys, with similar origins and development history have been selected, namely: Hyde

Park in London, the Tiergarten in Berlin, Clara Zetkin Park in Leipzig and Łazienki Królewskie Park in Warsaw. A similar history of their creation and development influenced their current natural structure and ecological functions.

The selected parks are characterised by a significant similarity of their natural environment. The results of the parks' natural environment study are shown in Table 1.

Table 1.

Natural structure of the selected parks

Characteristics of the natural environment	Parks			
	Hyde Park	Tiergarten	Clara Zetkin Park	Łazienki
Area in hectars	330	210	36	76
Location	over-flood terrace, plain	flood-plain terrace	flood-plain terrace	over-flood terrace, highplain
Surface deposits	silt, clay, sand	sand	silt and sand	sand, silt
Soils	luvisols, mollic gleysols	pararedzinas, gleysols, hortisol	fluvisols, cambisols	luvisols, mollic gleysols, cambisols
Groundwater [m] below ground level	up to 2, 2-5; above 5	up to 2, 2.5	up to 2	< 2, 2-5, above 5
Surface water	two ponds	a large pond, numerous small ponds and canals	pond	three ponds and canals
Actual vegetation	lawns, single trees (mainly plane trees)	lawns, park green loose and compact	fragment of a forest, lawns	fragment of a broadleaf deciduous forest (*Tilio carpinetum*), park green well-stocked and compact (predominance of domestic species)

Among the main ecological functions of parks are: ecological function of their soils, hydrological function, climatic function, biotic function and pollutant absorption function.

The **climatic function** of city parks alleviates the urban heat island, that is, it lowers the air temperature and increases its humidity, and contributes to favourable air circulation in the city. The topoclimate of a valley landscape is not favourable because of its excessive humidity, high daily amplitudes of temperature, temperature inversions, gravitational flow of cool air and its weak vertical exchange (stagnation). The wind direction is modified depending on the shape of the valley, in particular in the morning and evening, when air turbulence is weaker. Each of the parks described here fulfils its climatic function thanks to its natural potential, but the spatial scope and quality of the function depend mainly on anthropogenic factors. It seems appropriate to consider the climatic role of parks from the end of spring through the beginning of autumn, in particular in days with light overcast (0-2) and low wind speed (up to 2 m/sec). At such time the largest daily differentiation of the urban heat island intensity, as well as the strongest oppressive effect on organisms, occurs. The warmer the climate and the longer the vegetation period, the longer lasting is the influence of green areas on the climate during the year (for instance in London).

Thanks to the preserved active surface the local climate of parks changed little compared to the climate of forests, fields and meadows outside the city, in particular in their central areas. From May through October it is characterised by chilled air in the evening and night, and greater humidity during the day compared to built-up areas. Wide streets inside free spaces lead to partitioning of the heat island into several parts. For instance, the influence of the chilled air from above the Tiergarten reaches along the 17 Juni Strasse to Ernst-Reuter-Platz located 1 km west of the park.

In tree-covered parks located in valleys the wind speed decreases and calms often occur. This has an adverse influence on the air exchange with the surrounding areas. It was established that a weak wind (1.1 m/sec) and frequent calms (16.1%) in Clara Zetkin Park (Beziehungen zwischen ... 1996) are not conducive for the night exchange of cool air from above the park with the surrounding areas. In the park, the south wind predominates (coinciding with the direction of the valley), which created an additional obstacle for the penetration of the air to the built-up areas east and west. During the day the air stagnation and increased humidity in the park may cause the feeling of mugginess and decrease the level of comfort of its visitors.

In parks where lawns are predominant (Hyde Park, Tiergarten) the air also cools during the night. During the day the thermal conditions are not comfortable because of the free influx of the direct solar radiation to the surface of the area (lack of shade). The air from the park, penetrating to the adjacent areas, has almost the same temperature and does not alleviate the effects of the heat island. The air with higher temperature flows freely from above the built-up areas to the outskirts of the park. Therefore, outskirts of the park have a higher temperature. In the area of the Tiergarten two types of local climate have been defined: weakly changed climate (type 2) and moderately changed climate (type 3), compared with areas outside the city (Stadtklimatischen Zonen 1993). Type 3 occurs near the border of the park and along the main alleys, while type 2, in the remaining parts (Fig. 1). Type 2 is characterised by a moderate nightly cooling, a weakened wind speed and a moderate and weak feeling of mugginess on the body. In type 3 the nightly cooling is small, and the feeling of mugginess may be weak and moderate. The decrease of wind speed is moderate or small during most days and nights. The climate characteristic of these types is showed in Table 2.

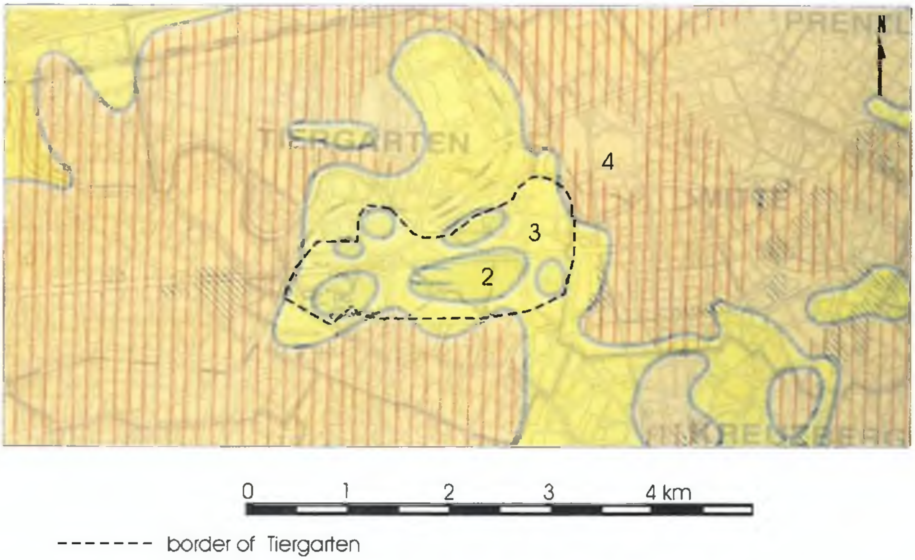


Fig. 1. Climate types in Berlin (source: Stadtklimatische Zonen, Umweltatlas Karten 04.05)

Table 2.

Characteristics of climate types in Berlin

	Kind of changes	Air temperature (°C)				Frosty days
		mean annual 1991/92	mean minimum 1991/92	mean daily amplitude 1991/92	mean annual 1961-90	
4	High	> 11.1	> 7.6	< 7.2	> 10.1	< 36
3	Medium	10.3–11.1	6.3–7.6	7.2–8.2	9.2–10.1	36–53
2	Weak	9.6–10.3	4.0–6.3	8.2–9.1	8.6–9.2	54–68
0	None	< 8.0	< 2.3	> 10.1	< 6.9	> 107

(source: Stadtklimatische Zonen, Umweltatlas Karten 04.05).

In parks located in valleys good humidity conditions are ensured not only by the vegetation, but also due to the presence of ponds with large surface (the Serpentine in Hyde Park, the Neue See in Tiergarten, Northern and Southern Pond in Łazienki), canals, as well as the occurrence of soils such as mollic gleys, fluvisols and hortisols. Compared with the surrounding areas, air humidity in parks is higher in the afternoon and evening.

In the winter air temperature in parks is lower due to the lack of energy emissions from artificial sources. There are more days with frost and near-ground frost in parks and the snow cover lasts longer, especially when the tree cover is thick (Table 2).

Examples of stationary research in small parks and their closest surroundings show that with a favourable wind direction and speed and without obstacles, the scope of climatic function may range from several tens to a few hundred metres (Shashua-Bar, Hoffman 2000, Vu, Asaeda, Abu 1998, Bruse et al. 2002). The extent to which parks located in valleys influence climate is restricted because of frequent air stagnation or inflow from higher-elevated areas.

The **biotic function** consists of creating living conditions for organisms, protection of genetic resources and valuable species of flora and fauna (especially domestic), introduction of new species, capability to produce biomass and its reconstruction, and ability of species to penetrate (Matuszkiewicz 1993). Parks fulfil the biotic function thanks to the biologically active preserved surface. For that reason parks are regarded as hub areas or hubs (depending on their area) in the natural system of the city. In this paper the biotic function of selected parks is determined by taking into account: the kind of vegetation cover and species of plants, age and structure of tree stand, bird species.

Each of the described parks satisfies most or all the criteria decisive for the biotic potential (Table 3).

Table 3.

Characteristics of biotic function of selected parks

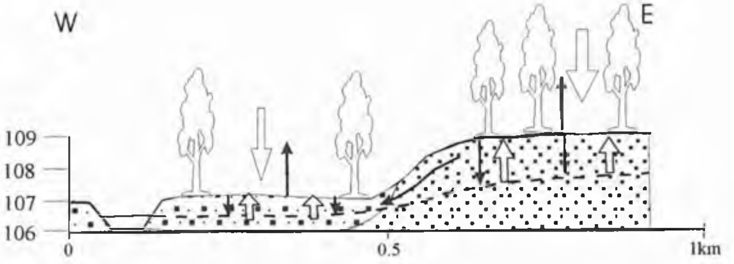
Features	Hyde Park	Tiergarten	Clara Zetkin	Łazienki
Kind of vegetation cover	Lawns Single trees Shrubs	Lawns Meadows Groups of trees Shrubs	Lawns Meadows Forest relicts Shrubs	Forest relicts Lawns Meadows Shrubs
Flora	Foreign species, such as plane trees and *robinia pseudocacium*, predominate		Broadleaf deciduous forest (*Tilio-Carpinetum*) and riverside (*Alno-Ulmion*) species predominate	
Age and structure of tree stand	100-300 years old Lack of undergrowth, gramineous ground cover	Less than 60 years old, gramineous ground cover	All-aged, Regular	All-aged, Regular
Avifauna	Rich (24 breeding species), mostly water birds	Rich	Rich, mostly forest birds	Very rich, Mostly forest birds (53 breeding species)
Biomass production	Large	Large	Very large	Very large

Łazienki Królewskie Park fulfils the biotic function to the largest degree. The conditions for plant and animal life here are favourable. The vegetation cover is varied, with a significant contribution from relicts of broadleaf deciduous forest (*Tilio-Carpinetum*). Numerous domestic species occur. Horticultural works are not intensive enough to interfere significantly with the circulation of matter. Similarly, Clara Zetkin Park performs its biotic function well. Fertile habitat and the predominance of broadleaf trees cause a large production of biomass in the area. The circulation of matter in the park can be evaluated as effective and close to natural conditions.

On the other hand, the role of Hyde Park and of the Tiergarten is weakened by the intensive recreational use. Trampled-upon lawns are being transformed into a collection of carpet grass, despite of land reclamation efforts (enrichment of the surface layer of soil by adding compost and peat, seeding of grass mixtures, irrigation). Tree-covered areas are characterised by a large share of plane trees (monotypification) with gramineous ground cover (the areas become cespitose). The number of species and the number of birds staying there is adversely influenced by the lack of vertical arrangement of vegetation and an intensive lawn care. The presence of many bird species in Hyde Park is due to its proximity to other green areas. Kensington Garden, Green Park and St. James's Park, bordering on Hyde Park, have more tree- and shrub-covered areas and constitute a potential habitat for birds, especially for forest birds, freely moving among the parks. The biotic function of the Tiergarten is much more stable than that of Hyde Park. The vegetation cover is diversified by meadows and groups of trees, which create a good habitat for forest birds. The presence of numerous ponds and canals ensures a habitat for water avifauna. An element that may weaken the function of this park is the lack of corridors ensuring biotic exchange with the neighbouring areas. The Spree River could accomplish the function of a corridor; unfortunately, its banks are deprived of any vegetation.

Soils influence many processes, such as: water circulation, geochemical circulation and spread of plant community. Among the basic **ecological functions of soils** are: supply of nutrients, water and air to the plants; filtering, buffering and transforming of harmful chemical substances, as well as creating habitat for organisms. Human actions weaken or strengthen the realization of these functions. In parks situated in valleys water conditions have changed particularly intensely. Moreover, anthropological material has been introduced to the soil profile; the vegetation cover and the surface relief have been transformed. All that caused changes to the mechanical and chemical characteristics of soils and their ecological function. Despite of that, in most cases the main soil-forming processes have not changed, and for this reason the soils of parks under investigation can be regarded as natural, especially underneath vegetation of natural or semi-natural character (northern part of Łazienki Park, Clara Zetkin Park). The most important change is that park soils do not constitute a habitat for broadleaf deciduous forest (*Tilio-Carpinetum*) and riverside forest (*Alno-Ulmion*).

The contents of nutrients in park soils depend on the parent rock, circulation of matter and human actions. Fluvisols in Clara Zetkin Park have the greatest natural abundance of nutrients (Fig. 2). Even when utilisation is extensive, they ensure the supply of appropriate components to the plants. In the Tiergarten, where loose and anthropogenic soils occur, maintaining soil characteristics favourable for the growth of vegetation requires intensive horticultural work. In luvisols, formed from silt and clay (western part of Łazienki Park, northern and central part of Hyde Park) nutrients are leaching from the upper levels. In parks with varied relief and substratum, nutrients discharged from the higher-elevated areas may enrich soils in lower-elevated places (Hyde Park, Łazienki Park).



Soil type		Anthropogenic fluvisols	Gley soil	Gleyic Cambisols
pH_{KCl}		7.2	5.8	5.6
CEC me/100g		20.3	21.8	20.8
C org %		6.9	4.8	5.3
Soil temperature		Cold	Cold	Cold
Water retention		Large	Large	Large
Cd	ppm	0.61	0.86	0.68
Cr		60.8	45.8	50.3
Cu		79.5	30.0	31.3
Ni		67.3	39.1	36.4
Pb		196.3	96.0	80.6
Zn		240.0	151.5	142.6

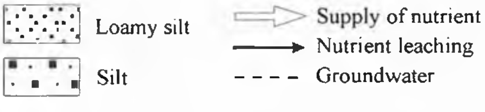


Fig. 2. Soil catena in Clara Zetkin Park (based on Schadstoffhaushalt in Böden ... 1995)

As mentioned earlier, in Łazienki Park, Clara Zetkin Park and in a part of the Tiergarten undisturbed circulation of matter takes place. Soils covered with compact tree or meadow vegetation are enriched in nutrients during humification and mineralisation of organic matter. Sodding and presence of shrubs and trees create favourable moisture conditions for the transformations taking place in organic matter. The degree of humification here is greater than in lawn soils and is equal to 37–44%. Humins form from 51–60% of general carbon (Kusińska 1991). In Hyde Park, due to the predominance of intensely cared for grass areas, the supply of mineral components from dead overground parts of plants is almost impossible, and the degree of humification is low. Therefore soils slowly degrade, both chemically and mechanically.

Differences resulting from the relief of terrain and surface forms also influence water and thermal characteristics of the soils, and these in turn affect the microclimate conditions and the local climate. Sandy soils (Tiergarten) have small thermal and water capacity; because of that, when the weather conditions are harsh (long-lasting draughts, sudden temperature changes), they are not capable of ensuring the optimal conditions for plants. This situation can be improved by such efforts as watering.

The best buffer conditions are characteristic for soils of large CEC (Cation Exchange capacity) and of neutral or alkaline reaction, such as fluvisols in Clara Zetkin Park (Fig. 2), cambisols and mollic glaysols in Łazienki Park and in Hyde Park. The worst buffer conditions are characteristic for loose soils of small CEC; such soils predominate in the Tiergarten.

Park soils carry out the ecological function to a varying extent. The more intensive human action is, the more this function is weakened. The following processes influence and restrict this function: acidity, erosion, nutrient leaching, lowering of the ground water level, intensive mineralisation, limited supply of organic matter. Such processes take place in each of the described parks. Fertilisation and watering may help improve the characteristics of soil. This method is costly, especially for soils formed from sands underneath lawns. In case of soils formed from silt and clay, efforts aiming at maintaining fertility and resistance of soils are much easier (Hyde Park, Łazienki Park, and Clara Zetkin Park).

The **pollutant absorption function** consists of the ability of the vegetation cover and soils to hold parts of gaseous and particulate substances contained in air and water.

Parks situated in the valleys have a large potential for absorption of pollutants. Being covered with tall and compact vegetation is the deciding factor here, but other factors also influence the scope of pollutant absorption. The analysis conducted here indicates that the following factors play an important role: climate of the area, soil and water conditions (Table 4).

Table 4.
Occurrence of factors favourable for pollutant absorption by valley parks

Factors conducive for pollutant absorption	Hyde Park	Tiergarten	Clara Zetkin Park	Łazienki
Compact, tall vegetation cover	-	+	+	+
Broadleaf trees	+	+	+	+
Low wind speed	-	+/-	+	+
High humidity	+/-	+	+	+
Soils with large sorption potential and alkaline soils	+/-	-	+	-\+
Shallow ground waters	-	+	+	-\+

Parks situated in valleys are under the influence of two pollutant streams: water pollutant flux and air pollutant flux. A park located on a flood plain terrace cumulates elements brought by surface and ground water, which can be seen in the chemical contents of the fluvisols (Clara Zetkin Park, Fig. 2). Forest parks, especially those with predominance of broadleaf trees, are able to hold more particulate matter and gases. Large general active surface, lower wind speed and larger air humidity act in favour of this taking place (Clara Zetkin Park, Łazienki Park). Some pollutants reach the soil due to rain and snow precipitation. When leaves are removed from the park in autumn, most pollutants are also removed with the leaves. Coniferous trees are the most vulnerable to the results of the accumulation of gases and heavy metals.

Parks where lawns predominate have smaller pollutant absorption potential. Additionally, this task is weakened by the action of wind, not hindered by any obstacles. Frequent mowing of grass eliminates the supply of most particulate matter and gases accumulated by the vegetation to the soils.

The presence of surface waters, high soil moisture and related to this high air humidity are factors reinforcing the pollutant absorption function. Particles of water steam catch gases and solid particles present in the air.

Phenomena characteristic for valleys, such as: air stagnation, temperature inversion, down slope air flow, generates favourable conditions for pollutant sedimentation; therefore, soils in valleys are vulnerable to a strong pollutant deposition from the atmosphere.

The reach of the partly cleaned air over the developed areas depends on the local air circulation. If the air does not encounter a significant obstacle then during the evening heat island, when warm air rises above the developed areas, cooled, cleaned air from above the park may be "sucked in" in place of the warm air (local urban breeze).

The degree of pollutant absorption depends also on the season. In London, the vegetation period is much longer, that is, the vegetation performs the described function for a longer time. There is also more rain in this city, and rain washes off dust from leaves to the soil.

The greatest pollutant absorption potential has soils with a large content of colloidal clay and humus with alkaline reaction (fluvisols in Clara Zetkin Park, mollic gleysols in Łazienki Park). At the same time, such soils have the greatest resistance (buffering) to toxic effects of heavy metals.

CONCLUSIONS

Valley parks in European cities perform an ecological function. This is related to a large extent to their location which influences the air and water circulation and the habitat conditions. In parks with a large number of trees the biotic function, the function of pollutant absorption is accomplished very well. The issue of the influence of a park on the surrounding areas is different in each individual case. If the park is surrounded by areas with compact, tall development, the sphere of its influence is limited. The proximity of other green areas, stretching along the valley, has a favourable influence on the biotic function (the possibility of species penetration). The climatic function is formed clearly in the summer, in the evening and at night. Because of that, one can talk about temporal and spatial dynamics of the way in which parks fulfil their ecological functions.

The trends observed in the parks under investigation can be applied to the majority of valley parks in European cities, located in warm moderate climate, in the zone of broadleaf deciduous forests shedding leaves for the winter.

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