SOILS IN LANDSCAPED PUBLIC AREAS

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Summary

Demands of public use determine the quality of urban ground and soils. On the other hand city history, location and availability of the ground have greater influence on the use than do the soil characteristics. In addition the use of the ground and the urban environment can effect the soil in an extreme way. This mutual relationship is pronounced for soils of parks, cemeteries and playgrounds.

To a minor extent, very old remnant areas survive in many cities. They can have well developed soil morphology, not touched by agriculture, of low maintenance input and are in many respects in a natural state, but which are under the impact of the environment of urban atmosphere. Often they are strongly acid and can be a source of groundwater pollution.

Most areas are exposed to landscaping by tipping and excavation. The reasons for this are numerous. New substrates are the body of soil formation. These soils are young and not much developed or stratified into horizons. Accumulation of humus will be visible, indicating that the soils are already sinks for carbon dioxide. An adverse characteristic of soils tipped in the last 30 to 40 years is strong compaction, which is not found to the same extent in rural areas. Compaction can be dominant. The result is a uniform low quality of surface urban soil.

Urban soils are often polluted by emissions and in part by the tipped man-made substrate. Children in particular will have direct contact with urban soils. Polluted soils can be a hazard to them, and special attention must consequently be given to children's playgrounds.

The problem of soil aeration is severe for burial grounds. Groundwater and stagnant water conditions decrease aeration. Lack of air circulation and the low redox potential

are also due to the high content of organic materials in the soil. The Nekrosols of cemeteries frequently will show reductomorphic features.

1. Introduction

In rural areas geogenesis of parent material and soil development are the main factors which influence the soil features. In urban areas the use of the site will often be an important additional factor. Different kinds of public use can cover large areas and can be numerous including parks, burial grounds, and playgrounds.

Truncation of existing soils and tipping of natural and man-made materials will change the morphology of the ground and the features of soils. Therefore the mostly young urban soils are on the one hand a reflection of the process of landscaping for the intended use and on the other hand of the impact of their actual use.

2. Parks

The areas covered by parks can amount to a large part of the green area of a city. The city of Hamburg, Germany, with a population of 1.7 million, and a density of 2260 inhabitants/km^2, has 9.2% public green areas, within which the 1450 parks of 3000 ha cover 45%. But the occurrence of parks varies between cities, and between city centers and outlying districts. Morphology and features of soils of parks are not uniform and are highly diverse. To date there exist few thorough descriptions of diverse park soils.

The roles of soils of urban park areas are many and varied. They are documents of the development of the city, material for landscape performance in a built area, and they fulfill many other functions. Many of the soils also preserve valuable remnants of the local nature before the city was founded or grew over the area.

We must note that there are numerous origins of park areas, and much variety in the ways they have been developed, used and influenced by the urban, industrial, socio-economic and built environment. All of these leave their imprint on the soils of parks.

The origin and reason for the establishment of parks are important factors affecting the morphology, degree of disturbance and heterogeneity of their soils. Table 1 summarizes a range of origins of parks. Some of them will mainly consist of soils of the original landscape. Others will be partially soils of natural material and partially soils that are in some way truncated. The modification will increase with the construction of walkways, monuments, and buildings, which result in import of mostly sandy, gravely and lime-containing materials. The groundwater table will be lowered to enable walking and lakes may be dug or refilled. The availability of parks as free areas makes them vulnerable to tipping or dumping unwanted material, most of which will consisting of earthy waste or rubble. On the other hand waste and mining spoil heaps, which cannot be used as sites for construction due to the low soil quality, do become parks. Therefore urban soil-forming materials are very diverse.

Obsolete parts of the cities—such as city walls and fortifications or ‘brownfield sites’ from abandoned industrial areas—often have the remains of any structures demolished, so that they can be transformed into parks. In some parts the soil surface of the original construction areas will be found, in other parts these areas are covered by natural soil material. The reasons for this covering are diverse. The ground has to be raised to be dry for walking; the original soil material at the site may not not suitable as a plant growing medium, or contaminated soil had to be covered by clean soil material, or surplus soil from other construction sites (e.g. for underground transportation or harbor construction) was disposed on the area.

Sites used since ancient times	Noble hunting ground, deer garden
	Cloister garden
	Cemetery
	Demolished fortification, walls, refilled moat
	City forest
Land unsuitable for buildings	River alluvium
	Wetlands, filled up lakes, ponds
	Lagoon deposits
	Irreclaimable former industry ground, only safeguarded by an additional soil cover
	Railway sidings
	Waste sites, heaps
	Mining spoil sites, heaps
	War rubble dumps
	Patches and strips to small to be build
	River alluvium
Parks as part of representative buildings and places	Palace park
	Manor house garden
	Residence park
	Monument park
Parks for entertainment	Kings and lords pleasure garden
	Garden exhibition
	Botanical gardens
City development plan	Aeration corridor
	District parks
	Accomplishment of business parks

Table 1: Some origins of park areas in cities

The practice of covering existing soil is widespread today. The result is relative uniformity of the soils of urban park areas of a city. The chance to establish in urban areas a high diversity of soils and natural areas is seldom used due to lack of knowledge about the properties of park soils and sites transferred into parks. Plots with soils of materials from demolished buildings (concrete and bricks); from cinders, mine spoil or slag; from construction of railroads or railway sidings; or an abandoned street can be valuable elements of the nature of urban parks.

The features of park soils will be further determined by the vegetation, management, general environment, and maintenance of the park.

Often the tipped or dumped material has little or no organic matter content. Increase of organic matter will occur relatively quickly over a period of 10 to 30 years. Young soils can be sinks of carbon dioxide. The process of organic matter accumulation is dependent on the success of the establishment of productive vegetation. There will be differences among trees, lawn and ornamental gardens. The site preparation for the vegetation will also influence the soil. The vegetation itself will have strong effects on erosion, air and household water, nutrient content, leaching of lime and nutrients, pH decrease, and filtering of pollutants from the atmosphere. All these processes will change the soil with time. Thus the soils are young and raw; and the signs of development and change appear rapidly. Accumulation of organic matter will increase the essential soil quality. Dense cover of large trees and bushes will hinder the growth of herbs so that the protective effect of a dense herbal or grass cover can be reduced. Erosion will occur either by precipitation or as a result of walking on the bare ground of slopes.

The most important effect of the use of park areas is the impact of walking and recreation. It compacts the topsoil, destroys the vegetative cover and makes the soil accessible to wind and water erosion. Parks also are dog-run areas. There is some perturbation and fertilizing of the soils by dogs. Park soils also receive human wastes and they can provide habitat for pathogenic microorganisms.

The surrounding city, as the environment of the park, will have an effect as the source of pollutants and of heat. Within 30 m of the streets there will be a pronounced accumulation of street dust and heavy metals such as lead. The other parts of the park will receive dust and pollutant emissions from the city.

The maintenance of park areas will have strong effects on the soils. Growing trees, mowing lawns, and removal of the grass off the site will result in a decrease of plant available nutrients and pH. Park soils should therefore be limed and fertilized at intervals but this is often neglected. That means many of the park lawns are poor in nutrient content, bio-mass production and low in pH.

Some examples of park soils are detailed here. The Hirschpark of the city of Hamburg has a 200 year old stand of beech trees. Strong emmission such as 0.10 mg SO_2/m^2 in 1980 decreased the pH. Decay of litter was inhibited by low pH and high exchangeable Al^{3+}-content leading to thick layers of litter and humus ($O_{L,}$, O_F, O_H) above the mineral soil (see Table 2). Rooting was mostly concentrated in the humus layer. Fine roots were damaged and mycorrhiza were not present.

Layers from tipped soil material can have high concentrations of carbonates and thus a high acid neutralization capacity. The pH is 7 or above. Heavy metals will be relatively immobile in this material. On the other hand they will be mobile in the natural soils of old parks due to low pH in the absence of liming. This brings up the curious situation that industrial soils contaminated very high by heavy metals are not as strong a hazard to the groundwater and to plants as are natural soils of parks which are contaminated to a lower degree. Table 3a and b shows examples from the Ruhr area of Germany.

Horizon	Depth	pH	ExchangableAl^{3+}	C_t	C/N
	cm	($CaCl_2$)	mmol/kg	%	
O_L	+15	4.0	-	47	26
O_H	+11	3.1	-	32	22
O_{FH}	+ 5	2.9	-	16	21
Ah	-10	3.2	26	6.0	25
Ah/Bv	-20	3.3	24	1.4	10
Bv	-30	3.5	20	2.1	-

Source: Meyer, 1986

Table 2: Decrease of soil quality by acidificationin a 200 years old beech stand

Horizon	Depth	pH	Zn	Pb	Cd	Cu	Ni	Pb	Zn	Cd	Cu	Ni
	cm	($CaCl_2$)	mg/kg, aqua regia extract					mg/kg, 1 mol NH_4NO_3 extract				
L	+4	3.7	262	365	1.3	53.5	16.0	4.3	7.5	0.7	1.5	5.3
Of	+3	3.2	209	242	0.4	62.9	16.2	14.0	34.3	0.3	1.6	4.4
Ah	-9	3.3	46	35	0.4	6.8	5.1	7.4	11.9	0.4	0.6	1.5
SwBv	-29	3.4	44	20	0.4	1.3	4.3	1.3	12.0	0.4	1.8	1.5
BvSw	-41	3.3	46	17	nd	4.2	7.8	5.0	7.9	0.3	2.0	1.5
Sw	-59	3.2	53	14	nd	6.3	10.4	2.9	7.4	0.3	0.3	1.0

Table 3a. pH and content of heavy metals in aqua regia (near total content) and 1 molammonium nitrate extract (available) of the natural soil of a more than 90 yearswooded mine lord park

Horizon (dominant material)	Depth (cm)	$CaCO_3$	pH	Zn	Pb	Cd	Cu	Ni	Pb	Zn	Cd	Cu	Ni
		%	($CaCl_2$)	mg/kg, aqua regia extract					mg/kg, 1mol NH_4NO_3 extract				
yjAh (loam)	-15	0	5.7	158	70	0.8	25	17.4	2.0	19.1	0.7	<0.1	2.8
yjBv (loam)	-39	0	5.5	67	28	<0.1	12	16.7	1.9	3.4	<0.1	0.8	<0.1
yjSw (ash,loam)	-50	1.4	7.1	230	59	0.8	102	4.3	1.0	2.0	0.4	1.9	<0.1
yjC (ash,loam)	-55	20.8	7.3	230	113	0.7	69	29.5	0.6	1.0	<0.1	<0.1	2.0
yC_1 (rubble)	-63	0.20	7.0	247	196	0.8	57	19.2	0.5	1.4	<0.1	<0.1	1.5
yC_2 (coal)	-79	0.20	7.1	172	52	0.3	46	16.4	2.4	1.3	<0.1	0.4	1.9

Table 3b: pH and content of heavy metals in aqua regia (near total) and 1mol ammonium nitrate extract (available) of a slightly brown and stagnogleyic Alloregosol from loess loam above ash loam mixture, rubble and hard coal

Most park areas are not fertilized. Their nutrient status will be dependent on the natural resources. Often they are exhausted by mowing and removal of the cut grass. Table 4 gives an example of the low content of available phosphorus. But there are also examples of enrichments by high amounts of dog excrements (Table 5). Potassium content is in both profiles sufficient according to the illite content of the loess loam.

Horizon	Depth (cm)	Bulk density g/kg	pH	C_{org} %	P available mg/kg	K available mg/kg	Air capacity	Field capacity	Avail. field cap.
							Vol.%		Vol.% Vol.%
Ah	-7	1017	5.7	4.26	47	771	7.4	55.0	32.2
$jcaC_1$	-15	1544	7.3	0.86	33	278	4.0	42.5	24.6
$hyjcaC_2$	-30	1641	7.4	0.70	43	301	3.5	34.9	15.6
jC_3	-45	1694	7.7	1.36	10	451	2.0	33.5	13.7
jC_4	-85	1705	7.0	0.93	26	355	1.7	33.9	16.7
yC_5	-92	1643	7.4	1.29	28	694	3.0	34.3	16.8

Table 4: Calceric Regosol from tipped loess loam mixed with rubble, age about 20 years

Horizon	Depth (cm)	Bulk density	pH	C_{org}	C/N	P available	K available
		g/kg		%		mg/kg	mg/kg
Ah_1	-2	1007	6.3	8.3	13.4	432	590
Ah_2	-6	1140	5.6	6.1	13.4	195	451
Ah_3	-9	1240	5.9	4.9	14.8	165	333
yjC_1	-14	1223	5.8	2.4	12.1	208	241
yjC_2	-27	1227	7.2	4.8	32.0	216	185
yjC_3	-43	1288	7.3	3.5	31.6	128	124
yjC_4	-48	1478	7.4	3.3	22.9	92	111
fAh	-61	1175	7.1	7.1	35.7	328	90

Table 5: Calceric Regosol from sorted war rubble material, age 50 years.

Table 4 and 5 demonstrate the large differences of bulk densities in park areas. Common to both examples is the low bulk density in the Ah horizon due to the high humus content resulting from prolonged mowing. Underneath the Ah-horizon the older soil stays loose but the young one is extremely compacted. The differences are attributable to the technique used for tipping. In 1950 the material was mainly tipped by hand and wheel barrow (Table 5). In 1980 the material was distributed and leveled by heavy machine. Manifold movements on the soil compacted it, and air capacity was reduced to a very low value. The plant available water at field capacity was reduced to moderate contents, which are unusually low for loess loam soils. At such sites there are problems of rooting because the seedlings trees do not take root and planting of trees must be repeated. This is an example of how today contaminated sites are very often covered by uncontaminated soils where heavy machinery is available. The result is that uniform and compacted surfaces are typical of city parks.

Nevertheless, the soils found in park areas are very diverse. Some can be the natural soils of the site, and sometimes they can be better preserved than in rural areas. But often they are modified or from tipped materials. When they are young they will have in the first 5 to 10 years features similar to the tipped substrate. They are Lithosols which can be subdivided into Autoliths from exposed natural substrates, Alloliths from tipped natural substrates, Technoliths from tipped man-made substrates (e.g. ashes, slag, rubble) and Phyroliths from mixtures of natural and man-made substrates.

The undisturbed nature of parks compared to other urban site uses means that park areas will undergo a visible soil formation which will differentiate the substrate layers to pedogenetic horizons. Humus accumulation will occur within 5 to 20 years and transform these soils to raw soils of less than 1% organic matter content which are called Syrozems. Increase of organic matter above 1% and thickness of Ah of at least 3 cm will result in Regosols or Calceric Regosols independent of the kind of substrate. Under stagnant and high groundwater conditions soil will develop which has similar features and household water dynamics as Pseudogleys (Stagnic Gleysols) or Gleysols. In periods of more than 50 years in some substrates first signs of browning are visible which indicate the start of formation of Brown Soils (Braunerde, Cambisols). Under conditions of high proton input from dry acid deposits and acid rain there will be features of Podsol formation in old parks, as weak podsolic soils occur.

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