POSITION OF SOILS AND SOIL-LIKE FORMATIONS OF FOOTBALL GROUNDS IN THE SOIL CLASSIFICATION SYSTEM

I. V. Zamotaev[1], V. P. Belobrov[2]

[1]*Institute of Geography, 119017 Moscow, Staromonetny 29*
e-mail: zivigran@rambler.ru
[2]*V.V. Dokuchaev Soil Science Institute, 119017 Moscow, Pyzhevskii 7, bld. 2*
e-mail: belobrovvp@mail.ru

Under consideration is the classification of soils and soil-like formations in special landscapes and the football ground in particular. The latter is usually represented by soils subjected to human impacts of varying intensity: from weakly transformed by technogenic processes to artificial soils or technogenic superficial formations. The objects of research are more than 40 football grounds in Russia and the Republic of Byelarus. They differ in the age (exploitation time), regular and intensive technogenic loads, natural conditions and soil properties. The football grounds under study were divided into 3 groups: sports-ground at the age of its exploitation (less than 5 years), sports-mass grounds (30-50 years) and professional football grounds (50-75 years). Every group of football grounds is characteristic of soils and technogenic superficial formations represented by (1) technogenic-natural soils, (2) technogenically transformed soils and (3) technogenic superficial formations. The first two groups include the surface-transformed and disturbed soils, the natural profile of which is weakly changed. The technogenic superficial formations artificially constructed on the buried horizons of natural soils are highly subjected to technogenesis. In dependence on natural and technogenic conditions, age or exploitation time, peculiar features of soil stratum on football grounds it is possible to recognize a postlithogenic type of soddy-podzolic soils as well as 3 synlithogenic types represented by techno-soddy podzolic soil and 2 types of technogenic superficial formations including primitive and soddy quasizems. The evolution trends are striving to develop three subtypes of soddy quasizems under all the bioclimatic conditions including lessive, gleyic and solonetzic ones, whereas under humid conditions of the Moscow region there exist 5 subtypes of techno-soddy podzolic soils represented by lessive, gleyic, technogenically overcompacted, residual-carbonate and chemically polluted ones.

Keywords: technopedogenesis, technogenic superficial formations, quasizems, age, type, landscape.

INTRODUCTION

At the current stage of the intensive society's development the problem relating to classification of natural and artificially constructed formations of biocosnic type including the soil is becoming increasingly common due to programs that make it imperative to set challenging tasks to create special purposeful landscapes such as flying airfields (urbo-transport landscape), grounds for playing golf (park-recreation landscape), football, base-ball, tennis, etc.

The construction of such landscapes requires a peculiar approach to the formation of the soil cover. It is necessary to meet specific requirements of morphological and physical-chemical properties of soils and soil-like formations, stratification of deposits and their homogeneity. In this group the man-made soils of sports constructions among which the football grounds are most distributed in the country and abroad have been so far examined insufficiently. They represent a peculiar recreation area of one hectare in size regularly subjected to intensive technogenic effects.

The technogenic effect on soils and football grounds in particular poses a serious hazard to the character and intensity of soil formation processes, the variability of soil properties and evolution what has every reason to consider technogenic effects as specific processes of technopedogenesis [3, 5]. The derivates of technogenesis are different surface natural and artificially constructed formations. The latter are represented by mechanically and chemically modified or disturbed soils that reveal little differences from soils with the natural profile. Among them are rehabilitated, contaminated, anthropogenically transformed and technogenic superficial formations [7]. Technogenic superficial formations (TSF) are combined into a group of soil-like bodies (soil-grounds, pedosediments, quasizems) to be characteristic for special landscapes.

To create football grounds, the specific technologies are required for the formation of the homogenous soil cover (soil-like formation) and its resistance to different natural, agrotechnical and sports effects. Besides, the artificially constructed soils of football grounds are needed in constant control over their evolution in time, the regular monitoring of their environment-geochemical state and adaptation to different natural-climatic zones in the country. As a consequence, the soil-like formations of football grounds need to be systematized and considered as objects of classification.

OBJECTS AND METHODS

The objects of research are soils and soil-like formations embracing not only professional football grounds but also those applied for the other sports purposes. Under study were 40 FG at the territory of Russia and the Republic of Belarus (Gomel town) that are quite different in the age (exploitation time), regularity and intensity of technogenic loads and natural conditions.

In geographical and bioclimatic respect these football grounds are located within the different altitudinal zones and geomorphological conditions; they were constructed on different soils underlying by various bedrocks at the different groundwater depth, what made it possible to elaborate the database for their classification.

The given studies were carried out using the soil-genetic methods including the comparative-geographical, landscape-geochemical and comparative-chronological ones. The field work evolved the morphological description of soil profiles and boreholes. The chemical, physical, agrochemical, microbiological, mineralogical and micromorphological properties of soils and soil-like formations were analyzed in laboratories of the Institute of Geography and the V.V. Dokuchaev Soil Science Institute.

The classification of soils and soil-like formations is based on the principles of Russian soil classification system published in 2004. They permitted to identify the evolutional and technogenic trend of changes in properties of soils with natural profile, soils weakly modified by the soil-forming process and technogenesis, the so-called disturbed soils and technogenic superficial formations. In view of classifying these soils all the studied football grounds (FG) were grouped in the following way:

1. The sports FG for sanitation training with small loads on the ground in the age of < 5 years; the building parameters to construct these fields have no standards (young FG)

2. The sports FG for popular sport training predominantly with moderate loads in the age of 30–50 years; the building parameters for constructing these fields are very simple and minimized;

3. The professional FG constructed by using definite standards and exploitation rules; they are subject to regular and intensive sports-technogenic effects; their age is 50–75 years (old FG).

RESULTS AND DISCUSSION

Every football ground in the above groups reveals specific soils classified as (1) technogenic-natural, (2) technogenically transformed and (3) soil-like technogenic formations.

1. *Technogenic-natural soils* are the surface-transformed native soils, the typical properties of which remained unchanged. This group of different-aged FG with insignificant sports-technogenic loads is represented by FG for schools, higher educational establishments, technical colleges and industrial enterprises.

They can be exemplified by the profile of soddy-pale-podzolic gleyic soil on mantle loams within the Moskva–Oka plain (pit 2-ДШ-07). The soil profile is on the football ground situated in the left bank of the Mocha river (Podolsk in the Moscow region; 55°20’29”N and 37°06’49”E). The morphological form of the profile is typical for zonal soddy-podzolic soil on mantle loams: Ad–A1–EIf–EL–ELBI(g)–BIt(g)–B2tg. The vegetation cover is represented by diverse grasses with admixture of gramineous ones (perennial rye-grass) and weeds (plantain, dandelion, colt’s foot, clever). The sanitation training takes place here only in the summer, 1–2 times a week.

In constructing the football grounds 30–50 years ago the topsoils were mixed with sand. At the present time they prove to be similar to the accumulative-humus horizon of natural soils under the grass vegetation. The transformed topsoils are loam-sandy coarse-silt and fine sandy in texture, eluvial horizons contain silt loam, the lower horizons – silt heavy loam. The physical-chemical characteristics well agree with natural analogs with the exception of the humus horizon. The reaction is neutral in the gray humus horizon, close to neutral is noted in the eluvial part of the profile (pH_{H2O} 6.3), with the depth of 30 cm in the ELBIt(g) horizon it becomes weakly acid (5.5). The absorbing capacity is not high. The humus content in the A1 horizon is 6.6%, it is sharply decreased with the depth and makes up 1.3% in the pale subhorizon and even 0.5–1.0% in lower horizons. Its composition in topsoil is humate-fulvate (Ch.a./Cf.a. = 0.5–0.6), in lower horizons it is fulvate; free carbonates are absent. The content of total P and N forms as well their mobile forms in the topsoil is close to that in forest soddy-podzolic soils, hence the exploitation of this football ground didn't change the properties inherent to initial natural soils. The sports effects were also insignificant to change the physical-mechanical soil properties. Only some parts of FG near the goal displayed grazing of the grass cover and degradation of the vegetable layer. The hardness and density of the surface horizons don't exceed optimal values (less than 20 kg/cm^2 and 0.9–1.3 g/cm^3 relatively) being characteristic of initial soddy-podzolic loamy soils. With depth the soil horizons become hard reaching 26–28 mm.

2. *Technogenically modified soils* are disturbed soils with artificial upper organo-mineral and mineral horizons 30–50 m thick. The examples are the following.

The pit 1-ДШ-07 is located on the football ground "Start" in Moscow (55^{o}39'03"N, 37^{o}33'10"E) constructed in 1970. In the vegetation cover that is absent in some places the rye-grass is dominant, plantain and clever are also met. The soil surface is compacted The morphological profile type of the techno-soddy-podzolic soil differs from that in technogenic-natural soils to a considerable extent: Ad–A1–IID1ca–IIIB1–B2–[VB1].

The pit 5-ДШ-07 – on the football ground "Nauka" in Moscow constructed in 1975. (geographical coordinates: 55^{o}49'58"N, 37^{o}32'22"E). In the grass cover different weed species are present; the penalty areas are often bare. The soil surface is compacted. The morphological profile type is Ad–A1–A1B1–IIB1–[IIIB1]. The upper horizons are represented by artificial organo-mineral material retreated by the soil-forming process and the earthworms. They are penetrated by grass roots being gray and brownish-gray in color. These horizons are compacted, well structured and have an admixture of sand and debris of carbonate and crystalline rocks. The thickness of the humus topsoil is 10–20 cm. Downwards the profile the subsoil mineral horizons are brown and yellowish-brown in color with the nutty or indistinctly expressed structure; they are different in texture being developed on artificial sandy, loam-sandy layers and sometimes their combinations 20–40 cm thick. The skeletal material displays several anthropogenic inclusions – remnants of construction materials, wires, coal particles, etc.

These horizons are intensively included into the processes of the soil formation and represent a transitional zone for ascending and descending flows of water and soil solutions. The illuvial humus and hard particles are accumulated in these horizons resulting from manifestation of such processes as lessive and partluvation. The silt-clay-humus infillings are observed on edges of structural particles. The lower part of the profile (III horizon) of these soils is represented by the buried subeluvial BE1 and/or illuvial B horizon of the native soil. In the B2g and B3g the traces of the gley formation are observed in the kind of bluish-ochric coloring. In total, these three horizons form a complicated natural-technogenic soil body or techno-soil. Its functional boundaries embrace natural substrata in the kind of residual horizons of soddy-podzolic soils. The physical, chemical and agrochemical properties of these soils reveal a great diversity along the profile.

Under agrotechnical effects (watering, mineral fertilization, technoturbation) the soil texture becomes heavy and the soil profile displays the increased differentiation of eluvial-illuvial type. The maximum of the clay fraction is noted in II and III horizons that is micromorphologically and analytically diagnosed in order to classify these soils as lessive soils. The excessive compaction of the topsoil (the density is higher than 1.53 g/cm^3 the hardness – 32 mm) makes it possible to recognize the *subtype of techno-compacted soils*. The varying content of carbonates (1.1–10.4%) is conditioned by the initial heterogeneity of human-deposited and underlying substrata.The soil reaction is decreased with depth practically in all these soils with the exception of soils enriched with residual pit gravel and debris of carbonate rocks. These soils are referred to the *subtype of residual-carbonate soils*. The Ch.a./Cf.a. ratio is varying from 0.48 to 0.58 and serves as evidence of prevailing the fulvic acids in the surface horizons. The different humus content is conditioned by the heterogeneity of organo-mineral horizons. With depth the humus content is decreased (1.2–1.4% at a depth of 40–50 cm) and indicates that the humus-illuvial process occurs. The humus horizons are quite different according to the content of the main nutrient elements due to initial heterogeneity of organo-mineral horizons resulted from their artificial formation and different amounts of mineral fertilizers.

Using the united approach to separation of technogenically modified soils according to the degree and the depth of effects it seemed possible to regard these soils to the group of techno-soils like as urbo-soils in the group of technogenically surface transformed natural soils [9, 3] and partially agro-soils (at a leve4l of types in orders of natural soils). The horizons of natural soils underlying technogenically modified ones give every reasons to determine the initial soil. In the Moscow region they are *techno-soddy-podzolic soils (lessive, gleyic, techno-compacted, chemically contaminated and residual-carbonate).* The further transformation of techno-soddy-podzolic soils is dependent on the prolonged period of pedogenesis and the effects degree of sports technogenesis.

As was mentioned above, the technogenically modified soils are typical for sports-popular fields and popular football grounds with moderate anthropogenic loads. They are considered as a definite stage of natural-anthropogenic (technogenic) evolution accompanying by changes in their regimes, processes and properties at all the transformation stages. The different parts of the soil profile on the football ground are subjected to sports-technogenic effects being dependent on their intensity and duration as well as on properties of initial soils. The classification position of these soils doesn't depend on the mechanisms responsible for sports-technogenic effects taking into account only their results reflected in the profile and properties of destructed soils.

3. *The soil-like technogenic formations* are included into the group of technogenic superficial formations [6] (Fig. 1). There are principal differences between them.

The soil-like technogenic formations (STF) are a specific group within the framework of technogenic superficial formations (TSF). As distinct from TSF the soil-like technogenic formations are constructed in their own image of the soil profile that is transformed into the soil under the influence of many factors very quickly as compared to the TSF and quasizems. TSF has no organo-mineral horizon and the term "soil-like" cannot be applicable for them. By this reason, it is more logic to use in classification the soil-like technogenic formations that are characteristic of football grounds with the grass cover. According to the profile form and properties we propose to identify the soil-like technogenic formations (STF) with the *primitive and the complete profile*.

Fig. 1. The typical profile of quasizem – technogenic surface formation (flying airfield “Domodedovo” in the Moscow region).

The 5-aged STF with primitive profile have a shallow humus profile (5–30 cm) comprising the vegetable layer (Ad) and the humus horizon (A1) with elements of the crumby structure. This horizon contains the inclusions of peat and fine rock debris. It is underlying by human-deposited non-humus mineral different-textured layers that haven’t been transformed by the soil formation process or reveal the features of illuvial soil processes.

3.1. The STF with primitive profile are the first stage of pedogenesis on FG being considered as analogs of natural weakly developed soils (Fig. 2). They are weakly developed due to a short period of time for the pedogenic transformation of the filled parent material. It gives every reason to regard them to *primitive quasizems* [1]. The example is the following:

Fig. 2. The morphological profile form of primitive quasizem (pit 2-ИЗ-06; the football ground “Spartak” in the Moscow region).

The pit ИЗ-1-01 (the football ground “Spartak” in Golitsino constructed in 2000) is located at the flat surface of the football ground under the filled layer of the well drained silt loess-like loam. The microrelief is vague. The grass communities predominated by white clever are quite different in their composition with projecting cover of 80%. The profile is rather simple: Ad–A1. At a depth of 25 cm is the subsoil horizon composing of fine granite and granite-gneiss fragments. In the lower part of the profile at a depth of 60–70 cm there is a system of horizontal drainage.

The pit 2-ИЗ-05 (the football ground “Dynamo” on Novogorsk of the Moscow region constructed in 2005) with the following profile: Ad–IA1_1–IIA$_2$–IIA1_3–IIID. The lower IIID horizon at a depth of 25–30 cm is underlying by horizons of the soddy-podzolic soil. In the field periphery the draining ditches reveal the reddish-brown moraine.

Among the primitive quasizems the carbonate and carbonate-free ones. In constructing the surface and subsurface horizons the sand enriched with carbonates was applied and resulted in the profile carbonation some years later. The primitive quasizems are differently provided with nutrient elements. The content of P_2O_5 mobile forms (20–163 mg/100g) in humus horizons is higher than that in the forest and agro-soddy-podzolic soils (5–10 to 60 mg/100g) but rather low as compared to urbozems in Moscow (250 mg/100g). The content of mobile K_2O (7–47 mg/100g) is increased by 2 times in comparison with the soddy-podzolic soils, agrozems, the soils in botanical gardens and urbozems in Moscow [9]. The topsoil of primitive quasizems is enriched with the organic matter; its content makes up 6–13%. In a number of soil-like technogenic formations the humus content is rather low (3%). The analysis of the group and fractional humus composition showed that the Ch.a./Cf.a. ratio is identical to the Ca-humus soils where this ratio is 1.0–1.3. In topsoils of primitive quasizems the humic acids are dominant. The nonhydrolyzed residue characterizing the stable fixation of humus substances qith the mineral part of STF varies from 53 to 67% of the total carbon content.

Primitive quasizems in their properties are close to analogs of natural weakly developed soils. The short period of time is insufficient for pedogenic transformation of the artificially created parent material and includes three groups of processes: (1) transformation of the inherited organic matter by microbiological processes and the humus accumulation, (2) structural reorganization of the solid phase due to the development of the grass root system and mixing the material by micro- and mesofauna, (3) translocation of fine and silt particles – lessive and partluvation.

Primitive quasizems as a small group of "technogenically transformed soils with the filled humus layer" can be referred to technozems [4] or "constructozems" consisting not only of the human-deposited fertile humus layer but also several different-textured ground layers [9, 3].

In soil classifications of foreign authors these soils are named as Anthroposols or Anthrosols, in the WRB system they are Technosols.

3.2. The soil-like technogenic formations with the *complete profile* are soddy quasizems, they are typical for football grounds constructed 30, 50 and 75 years ago. Their upper part is represented by sod cover and humus-accumulative horizons. Downwards the profile the horizons are yellowish-brown and brown in color with indistinct structure and different texture. Sometimes they are cemented and reveal the silt-humus-clayey illuvial infillings. Between the layers there are traces of contact gleying. In some profiles the solonization process takes place in the kind of the highly compacted surface horizons, the formation of blocky aggregates and the increased amount of exchangeable sodium in the soil absorbing complex. The subhumus horizon is identical to natural illuvial soils to be a transitional zone for ascending and descending flows of water and soil salt-saturated solutions. At the same time, this horizon displays the accumulation of solid clay particles as a result of lessive process and at least this horizon is an active zone for oxidation-reduction reactions and hydromorphism (gley formation). Together with the buried horizons in the STF the complete profile is developed with time. As an example is the pit И3-3-00 located on the football ground "Spartak" (Fig. 3). It has been constructed in 1935. In the vegetation cover the rye-grass and meadow grass prevail. There is plantain with admixture of white clever. The profile type is Ad–AI_1–AI_2–IID–IIID2–IVD3–[BI(g)]–[B2(g)]–[IID] – 100–120 cm. The soddy quasizems are heterogenous in their physical and chemical properties

Fig. 3. The morphlogical profile form of soddy quasizem (pit 2-И3-00, the football ground "Spartak" in the Moscow region).

being different in texture and differentiation pattern, although in the major cases they are loam-sandy and fine-loamy. Their pH is varying from weakly to strongly alkaline. The higher alkalinity is associated, on the one hand, with application of high rates of lime and the fertilizers of low-quality, for instance nitrophoska and azophoska and, on the other hand, the carbonate material in the kind of numerous inclusions that has been introduced into the soil during the FG construction and sanding. The variability of the carbonate content from 0.5–9.7% in humid regions and 6.8–16.6% in arid regions is conditioned by natural-climatic conditions and the initial heterogeneity of artificial substrata. These differences are disappeared at the expense of agrotechnogenic effects (fertilization and sanding) and with time the carbonation takes place not only in the topsoil but also the entire profile. This process is rather intensive and even the watering cannot decrease the soil alkalinity. The amount of humus and nutrient elements is quite different in every concrete FG in dependence on the time of its exploitation. The humus content in topsoils of STF is estimated as the increased one especially in football grounds constructed many years ago resulted from prolonged fertilization, watering, aeration, earthing and the other management practices. The topsoils reveal a great amount of weakly decomposed organic matter. All the STF are provided with the total nitrogen. Agrochemical indices are highly varying in topsoils especially the content of P_2O_5 and K_2O. The influence of fertilizers n the grass cover and topsoils is not systematically controlled what leads to decreasing the efficient application of fertilizers.

A tend to increasing the texture differentiation in the profile of STF is observed in dependence on the time of the STF exploitation. The texture becomes heavy probably due to input of the humus and fine-dispersed material into the soil in the course of earthing. The maximal amount of the clay fraction is found to be in subsoil horizons and at the contact with buried ones that is micromorphologically diagnosed and permits to classify the STF as lessive ones. In view of this, it is worthy of note that the STF evolution is conditioned by technogenic processes The application of fertilizers and pesticides, the atmospheric dust lead to contamination, technogenic carbonation and increasing the alkalinity. In some cases the contamination by arsenic and the other heavy metals becomes hazardous, for example the FG “Dynamo” in Moscow (Fig .4). According to this feature the STFs are close to anthropogenically transformed soils in the order of chemozems.

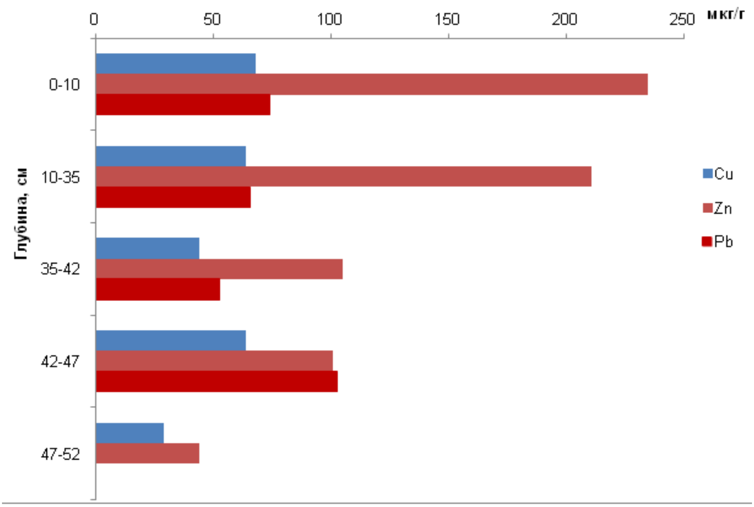

Fig. 4. Distribution of the total content of heavy metalsalong the profile of the soil-like technogenic formation in the football ground “Dynamo”, Moscow).

Chemozems are anthropogenically transformed soils identifying only at a level of orders now. However, the technogenic contamination of STFs doesn’t cause visual changes in the profile and has no influence on the grass cover as compared to chemozems. The formation of STF occurs under specific natural-technogenic conditions, they reveal a combination of properties and features that have no analogs among the known soil types. It is possible to observe in STF the single-oriented elementary soil-forming processes and the development of several models of pedogenesis.

The “ideal” pedogenesis (normal model) is combined with techno-and zooturbation (turbated model) as well as the human-induced chemogenic material (accumulative-chemogenic model) and the other material onto the STF surface (accumulative-sedimentary model). The given processes lead to different results. The processes of pedogenesis cause vertical differentiation of the profile in STF. The input of allochtonic material resulted from sanding and earthing leads to increasing the profile thickness that gives every reason to relate them to the trunk of synlithogenic soils and to recognize orders, types and subtypes (Table).

Classification of soils and soil similar man-made structures football fields

Trunk	Order	Type	Subtype
Postlithogenic	Technogenic-natural	Soddy-podzolic	Typical, oddy-pale-podzolic, gleyic
Synlithogenic	Technogenically modified (techno-soils)	Techno-soddy-podzolic	Lessive Gleyic Techno-compacted,
	Soil-like techno-genic formations	Primitive quasizems soddy qua-sizems	Chemically con-taminated Residual-carbonate Carbonate Carbonate-free Lessive Solnetzic Gleyic

At the lower taxonomic levels the quasizems can be distinguished according to the thickness of the humus horizon (10 cm – weak, 10–20 cm – medium, 20–30 cm – strong), the humus content (3–5% – medium-humus, 5–8% – highly humus and >8% – rich). According to texture of the organo-mineral topsoil the soils are divided into loam-sandy, fine loamy, medium loamy and heavy loamy ones.

The character of natural and artificial inclusions is dependent on drainage system and the amount of debris of crystalline rocks and artificial materials.

CONCLUSION

Based upon the soil-genetic methods it was possible to study and typify the technogenic-natural soils of sports fields, technogenically modified soils of sports-popular grounds and the soil-like technogenic formations of professional football grounds in humid and arid zones of Russia as objects of complex effects exerted by technogenic and natural processes.

It has been established that the soil-like technogenic formations of football grounds are peculiar natural-tehnogenic biocosnic formations (STF) developed under the influence of natural processes and the sports technogenesis. The natural-technogenic profile of STF is a polygenetic formation in which the soil-genetic interactions are manifested between the artificial and underlying parts of the profile and the organogenic and mineral components in the artificial part of STF.

In dependence on the natural-technogenic conditions, age (time of exploitation) and the peculiar form of the soil profile in football grounds it became evident to recognize the postlithogenic type of soddy-podzolic soils and synlithogenic types including techno-soddy-podzolic soils and two types of soil-like tehnogenic formations – primitive and soddy quasizems.

Under all the bioclimatic conditions the evolution trends are capable to develop three subtypes of soddy quasizems: lessive, gleyic, solonetzic but in the humid zone of the Moscow region – five subtypes of techno-soddy-podzolic soils including lessive, gleyic, techno-compacted, residual-carbonate and chemically contaminated soils.

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