

Effects of recreational load on soils of footpaths and their impact zones in the Moscow forest parks

G.V.Stoma, V.A.Kuznetsov

Moscow State University, Moscow, Russia

gstoma@yandex.ru

Forest ecosystems in urbanized areas perform the important ecological function, supporting favorable natural habitat. Stability of their functioning depends on features of ecosystems, the status of all tiers of vegetation and soil properties. When using forest parks as an object of recreation formed by road and path network which breaks the integrity of natural components forest park. According to the level of recreational influence footpaths, near footpaths zones (impact zone) zones and the least undisturbed “core” are allocated. Each of these areas has specific characteristics, and their ratio is reflected in the general ecological condition of forest parks. In the conditions of the city influence of recreation is supplemented with the general atmotechnogenic deposition, containing carbonates, and local – carbon-containing connections and readily soluble salts.

The purpose of work was assessment of changes in the soil properties of footpaths and their impact zone depending on the level of recreational load and features of biogeocenoses.

Two large Moscow forest parks (“Losinii ostrov” and “Bitsevskii forest”) which are actively used for recreation served as objects of research. In each forest park 9 areas, on three with different degree of manifestation footpaths are chosen (slightly, moderately, well-defined types). The last was estimated on their width (to 50, 50-80 and > 80 cm), to projective covering of live ground cover (to 5, 5-10 and > 15%) and consolidation depth (to 5, 5-10 and > 10 cm). On gradient from footpaths to the forest area (directly on them and at distance of 20, 50 and 100 cm from their edge) on layers of 0-5, 5-10 and 10-20 cm selected samples in 12 multiple repetition. The areas characterizing a little disturbed biogeocenosis “core” at the I digression stage (DS) served as background. Fir-tree linden-forest on sod-podzolic sandy loam soils on the integumentary loams spread by fluvio-glacial deposits and oak-linden forest on sod-podzolic medium loamy soils on the integumentary loams spread by a moraine were respectively studied in “Losinii ostrov” and in “Bitsevskii forest” (Album Retisols on WRB, 2014). On footpaths their superficially gleyed differences prevailed. Characteristics of litter and properties of soils estimated by the standard methods. Data processing was carried out in STATISTICA package. The chosen level of significance was 0.05.

The type and specifics of the wood defined distinctions of characteristics of litter, and different particle size distribution of parent rocks - soil properties. In “Losinii ostrov” in comparison with “Bitsevskii forest” soils have smaller capacity of humus horizons, content with organic matter, less favorable structural state and bigger acidity. Patterns of change of litter and soil properties from footpaths to the forest area in forest parks are identical, and some differences are connected with features of biogeocenoses.

The underlayer of the litter. Under the influence of recreation in forest parks degradation of litter is observed. In comparison with the background its power on footpaths decreases from 2-4 cm to fragmentariness, type – with humified on destructive. Reduction of stocks of litter and width of formation of impact zones correlate with the degree of manifestation of footpaths. On sites with low of manifestation level footpath there is litter stocks reduction (in 1.8 and 1.6 times) which is fixed only on footpaths, with average level (at 1.4-1.9 time) extends to 20 cm from their edge, and well-defined types footpath (at 1.4-2.3) - to 50 cm. More intensively it is shown in “Losinii ostrov”.

Crushing and grinding during the trampling organic material of litter lead to the reliable decrease in share active, to increase in the passive and crushed fractions. At the initial stage of recreation in oak and linden forest change of share structure of fractions (1.3-6.5 times) is less in comparison with fir-tree linden-forest (1.4-7.4 times). As much as possible process is shown on footpaths with width of impact zones before 50 cm. On sites with moderately and well-defined types footpaths on the contrary: in “Bitsevskii forest” change of fractions of laying is more essential, than in “Losinii ostrov” (in 1.3-13 and 1.3-7.7 times, respectively). The impact zone extends to 100 cm. It is caused by bigger pliability for decomposition by microorganisms of sheet litter in comparison with coniferous and sheet.

The humidity of litter as a result of transformation of its structure and decrease in water permeability of soils increases from background 20% up to 22-36%. Its statistically reliable increase in “Losinii ostrov” is noted on moderately and well-defined types footpaths and in impact zone of the last to 50 cm, and in “Bitsevskii forest” - only on their well-marked options.

Changes in soil properties under the influence of recreation

Density (ρ_b). The recreation promotes compaction in all 0-20 cm of layer soils. Directly on footpaths (except slightly defined types footpaths) size ρ_b (1,40-1,74 g/cm³) exceeds optimum ranges. In “Losinii ostrov” reliable consolidation (on 0.17-0.35 g/cm³) is fixed in all studied layer of the moderately defined types footpaths and in 20-50 cm from them. In “Bitsevskii forest” it is less (on 0.07-0.15 g/cm³) and is also shown only directly on footpath. At intensification load increasing ρ_b extends to 50-100 cm from edge of footpaths in the first case and only to 50 cm in the second. More deeply ρ_b is in “Losinii ostrov” already on slightly defined types footpaths and in 20 cm from their edge, and in “Bitsevskii forest” only on moderately defined types footpaths. Possibly, it is caused by “exhaustion” organic the profile and approach to the surface of the facilitated eluvial horizon.

The hardness of soils. Regularities of its change under the influence of recreation are similar to the density of soils. However, increase in hardness in comparison with the density of soils in upper layer is shown quicker: statistically significant distinctions (at 1.3-1.7 time) are fixed already on slightly defined types footpaths.

The structural condition of soils negatively reacts to recreation. The coefficient of structure degree (Kstr.) in layer of 0-5 cm authentically decreases at 2-13 times concerning background in all points of approbation, as much as possible - on footpaths. In “Losinii ostrov” on slightly defined types footpaths the structure quality is still “good” (Kstr.=0,81), and on moderately defined types footpaths is already “unsatisfactory” (Kstr. <0,67). Deterioration in structural state (Kstr. <1.5) is shown in 20-50 cm from edge of footpaths. In “ Bitsevskii forest “ the structure of soils is steadier against recreation. The process of its degradation proceeds more slowly: “unsatisfactory” state (Kstr. =0,39-0,44) is fixed only on moderately defined types footpaths. In impact zones, despite falling Kstr. by 1,6-2 times, its size > 1,5, quality of structure of soils is characterized as “excellent”.

The humidity of soils in upper layer significantly increases (by 2-14%) on footpaths and in 20-100 cm from them; most in “Losinii ostrov”. Enrichment of underlying layers of soils moisture is less (for 2-6%). In “Bitsevskii forest” it is noted on footpaths and in 20 cm from its edge, and in “Losinii ostrov” – in 20-100 cm. Distinctions are caused by water retention power, the moisture movement conditions, particle size composition.

The maintenance of organic carbon in 0-20 cm layer of soils changes in different directions and is defined by balance of its receipt and losses.

In upper layer of soils of forest parks identical consistent patterns of enrichment of Corg (by 1.4-2 times), proportional to the level of recreational load are determined. Enrichment is connected with the introduction in it the incorporated fragments of litter and increased of biochemical destruction of litter and anthropogenous contribution. In “Losinii ostrov” reliable increase is shown on slightly defined footpaths types, and in “Bitsevskii forest” only on moderately defined types footpaths. Width of impact zones on moderately defined types footpaths makes 20-50 cm and on sites with on well-defined types footpaths - extends to 50-100 cm. As a result of the accumulation of humus and “compression” organic the profile more deeply the maintenance of Corg changes in different directions.

Reaction of the environment. Reliable increase pH of water on 0.4-1.4 on footpaths and along them to 50-100 cm in upper layer of soils of “Losinii ostrov” depends on degree of recreational load. In underlying layers process is not certain. In “Bitsevskii forest” in layer of 0-5 cm the shift of reaction in the neutral party is less (0.3-0.8 pH of water), and impact zones already (at all footpaths - 20 cm). Regularities remain in deeper layers. On urban areas intake of the atmotechnogenic deposition containing calcium carbonates and magnesium and effects of application of anti-icing connections is the main reason. It is confirmed by increase of pH of water (on 0,7-1,1) and turbidity (at 2-12 times) snow melt-waters in comparison with background.

Electroconductivity (Ec) of soils in upper layer increases (by 1.25-3.9 times) as a result of use of anti-icing connections on highways and the yards which with eolian transfer and at winter recreation come to forest

parks. This fact is confirmed by the Ec of thawed snow, increasing in comparison with background by 2 - 10 times. At the low level of recreation reliable differences it is fixed only on footpaths, and at its intensification the impact zone 20-50 cm wide forms. Deeper size of the Ec of soils 2-3 times lower. Dependence of its change on gradient in "Losinii ostrov" is absent, and in "Bitsevskii forest" remains with expansion of impact zones to 100 cm. Distinctions are caused by easier particle size distribution of soils of "Losinii ostrov" strengthening the descending migration of electrolytes.

Biological activity of soils at recreation can both amplify, and to go down. As the reason serves transformation of ecological conditions that promotes change of physiological condition of microorganisms and reorganization of their complex. Significant distinctions of size of basal breath of soils is not established. There was a only the trend of its decrease concerning background at weak recreational load to 20 cm from footpaths is tracked, and increase while enhancing recreational load. The substrate-induced respiration (SID) is more indicative. In soils of "Losinii ostrov" its reliable increase (by 1.6 times) is shown only on well-defined types footpaths. In "Bitsevskii forest" the microbial community of soils reacts to stressful situation more quick outbreak of his activity. Reliable differences of SID from background (at 1.2-2,2 time) are fixed already on slightly defined types footpaths, and further and in 20-50 cm impact zones.

The condition of complex of soil invertebrates at recreational load also changes. In comparison with background in layer of 0-20 cm their number (by 1.3-4 times), biomass (1.1-16 times) and variety decreases (by 1,5-4 times) up to formation of monodominant communities (earthworms dominate). Width of impact zones increases from 20-50 cm up to more than 100 cm. Most negatively react soil invertebrates of litter complex .

The conducted researches showed existence of dependence between the level and depth of change of soil properties, width of impact zones and degree of manifestation of footpaths. Density, hardness, structure of soils and condition of complex of invertebrates are the most sensitive to recreational influence. Chemical properties of soils are less informative. Soils of forest park "Losinii ostrov" in comparison with "Bitsevskii forest" as less rich in organic matter, more acid and more light granulometric composition are more vulnerable to recreation.