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Research Article

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Condition Assessment of Tree Plantations and Phytosanitary Properties of Soils in Cedar Groves

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ABSTRACT

Indicators of sustainable development of the city represent the quality of the urban environment, creation of an eco-friendly urban environment is up-to-date trend of modernity. The preservation of soil fertility, the quality of land resources, their rational use, as well as the maintenance and conservation of vegetation cover are one of the indicators of the ecological aspects of sustainable development. The complex assessment of an urbanized environment state consists of condition assessments of many components, one of which is a soil cover. In the study of this component, a lot of attention was paid to microbiological research. The microbiota, the microbiological parameters of the soil cover, and its biological activity are first changed under the anthropogenic impact; so, many researchers consider them to be the most sensitive indicators of soil contamination.

Keywords :*Ecology, cities, soil, pollution, heavy metals*

INTRODUCTION

Urban (urbanized) environment is a system of natural, natural-anthropogenic (technogenic) and socio-economic conditions that can have a significant impact on the inhabitants of cities. Indicators of sustainable development of the city represent the quality of the urban environment, creation of an eco-friendly urban environment is up-to-date trend of modernity. The preservation of soil fertility, the quality of land resources, their rational use, as well as the maintenance and conservation of vegetation cover are one of the indicators of the ecological aspects of sustainable development.

Sanitary and microbiological assessment of the soil cover is an important part of the conduct of preventive and current sanitary control of the soil cover condition [1-4].

This work is aimed at studying the soil conditions of cedar groves; it is important contribution to improving the ecological situation in the Gryazovets district. Cedar forests in the investigated objects have important recreational,

sanitary, hygienic and reproductive significance. To create healthy cedar plantations, it is necessary to take into account a number of factors in the growing process, one of the most important is the soil, namely its microflora and microbiological indices associated with the rhizosphere part of cedar, as well as the content of heavy metals in the soil cover.

Objective: to study microbiological parameters and population of soil microorganisms in cedar plantings in the Gryazovets district.

MATERIALS AND METHODS

Siberian pine (Pinus sibirica Du Tour), valuable nut-bearing breed that has perfectly adapted to the climatic conditions of the area, grows in the cedar groves of the Gryazovets district. Groves are characterized by cultural, historical, recreational and aesthetic values. Carrying out microbiological research, namely the detection and quantification of microorganisms in the soils of cedar groves is an actual trend of the present, which is necessary for maintaining the hygienic characteristics of groves, preservation of valuable tree species, modeling and developing environmental protection measures [4].

The first investigated object is the cedar grove in Chagrino, it is a botanical monument of nature of regional significance dated 29.01.1963, located in the Vologda region, Gryazovets municipal district (Municipality Komyanskoe, Chagrino village), the area of which is 3.7 hectares [5]. The grove in Chagrino is located at the junction of the Vologda upland and the Prisukhonskaya lowland in the form of an elongated quadrangle. A grove with oak, Norway maple, small-leaved linden, ash and common hazel, as well as Scots pine and Siberian pine were founded in the Chagrin manor in the second half of the 19th century (planted by the landowner N.A. Petrov in 1900-1901 near the village of Shipyakovo). It was laid by 5-10-year-old pine trees, which were planted at a distance of 10×10 m [5].

To date, park has 28 rows of old plantations, in each row there are from 4 to 22 trees up to 12 meters high. The most powerful trees are from 60 to 80 cm in diameter located in the middle of the plantations on a small hill. In the early 90's, young 15-, 20-year-old Siberian pines, small-leaved lindens and spruces were planted. By now, 133 Siberian pines with powerful trunks have been preserved in the grove, the average height of which is 19.5 m [4].

The second object of research is the Gryazovets cedar grove, which was laid in 1966. The area of the grove is one hectare. About 300 six-year-old seedlings of Siberian pine, which were grown first in greenhouses and then in open ground, were planted in a grove. Beforehand the area was plowed, cultivated and drilled. Plants were planted at the distance of 4×4 meters. Landing site was prepared with the introduction of the manure, compost mixed with sand and mineral fertilizers for each seedling. Ditches were dug along the perimeter of the territory. In the early years, agrotechnical care for trees was conducted by students of the local technical school. In the center of the grove, the date of creation of this plantation is monumentally perpetuated in the form of a memorable sign. At present the plantation is represented by 218 Siberian pines of different life state with an average stem diameter from 20 to 30 cm [4].

The samples of soils were taken in the spring, summer and autumn periods of 2016 to conduct microbiological studies. Samples were taken using a scoop in the circles around trees (5 points around the trunk) from a depth of 10-20 cm from each part of the grove. The top layer 3 cm thick was removed in order to avoid the ingress of foreign microflora. The analysis of the samples was carried out by the generally accepted method of microbiological soil analysis. The parameters of the total number of growing bacteria and fungi were determined using the method of luminescence microscopy. The method consists in staining soil preparations with special dyes. Under the influence of the dye, the cells begin to glow, and they are clearly visible on the dark background of soil particles and preparation. Calculation of the number of cells, spores of fungi and fungal mycelium per 1 g of soil was carried out according to the formula: $N=S_1 \times a \times n / v \times S_2 \times c$, where N - number of cells, fungal spores and length of fungal mycelium (μm in 1 g of soil); S_1 - the area of the preparation (μm^2); a - number of cells (length of mycelium, μm) in one field of view (averaging was performed for all preparations); n - the dilution index of the soil suspension (ml); v - the volume of the drop applied to the glass (ml); S^2 - the field of view of the microscope, equal to 10 000 μm^2; c – weight of the soil sample (g) [6].

The agrochemical analysis of soil samples taken in the investigated cedar groves was carried out. This measure is carried out to determine the degree of provision of soil cover with basic elements of mineral nutrition, the hydrogen index and the degree of organic matter content. The analysis was carried out in the Agrochemical Center in the village of Molochnoe. Also the assessment of the degree of chemical contamination of the Chagrino and Gryazovets

cedar groves soils was made. It was carried out with the help of sanitary and hygienic rationing of the content of heavy metals (Mg, Cu, Ni, Co, Pb, Cr, As, Zn) in the soil-vegetation cover by correlating the actually determined concentration of elements with the maximum permissible concentration (MPC) [6].

The forest inventory was made to assess the condition of cedar groves [7]. To assess the growth and development of tree plantations, there are methods for identifying the sanitary status of individual trees. The categories of trees according to the sanitary state: I - without signs of weakening; II - weakened; III - strongly weakened; IV - drying up; V - fresh dead (current year); VI - old dead (last years) [8, 9].

RESULTS AND DISCUSSION

A taxation description of cedar plantations in the Chagrino and Gryazovets groves was carried out on indicators describing qualitative and quantitative characteristics: age, number of trees in the grove, average trunk height, average trunk diameter, and average crown diameter. By the present time, on 3.7 hectares of Chagrino grove 133 cedars with powerful trunks have been preserved, the average height of which is 19.5 m. In the Gryazovets grove, the area of which reaches 1 hectare, 76 cedar trees with an average trunk height of 12 m were preserved. Thus, in the Gryazovets grove (age 47) the average diameter of the trunk is 25 cm, and the average width of the crown is 3.7 ± 0.1 m; in the Chagrino grove (age 114) these figures reach 62.1 cm and 6.9 m.

In practice, the categories of the condition of tree plantations are an integral measure of their weakening or viability. In the distribution of trees by class of sanitary condition, most of them are classified as second class (43% and 49%). Tree plantations of I, II and III class are completely viable. The difference from withering and fresh deadwood is that the probability of their death is not determined; it is more likely to be accidental than expected and natural. There is no reason to expect the desiccation of trees of these categories in the near future.

The average weighted value of the sanitary assessment for the Chagrino cedar grove is 2.0, for Gryazovets grove this indicator is slightly higher and is 2.3. Based on this indicator, it is necessary to draw a conclusion about the weakened state of these plantations. Low estimates in these groves are associated with the withering away of the branches in the lower part of the tree crowns.

Agrochemical analysis of the soil is an activity that is carried out to determine the degree of provision of soil cover with basic elements of mineral nutrition, humus content, hydrogen index and degree of saturation with organic matter [9]. The percentage value of humus content in the investigated samples is estimated at an average of 4.87 %. In the Gryazovets cedar grove, the percentage of humus is slightly higher than in the Chagrino cedar grove, in the first it is 5.15 %, and in the second - 4.59 %. The acidity of the medium is measured in units of pH. In the studied soil samples, the value of this indicator is 5.2 (Chagrino cedar grove) and 5.1 (Gryazovets cedar grove), the medium is slightly acidic. The value of acidity is suitable for the growth of coniferous trees.

According to the content of phosphorus and potassium oxide, calcium and magnesium, the values in the studied samples are similar and correspond to the average saturation of soil cover by the basic elements of mineral nutrition.

The soil cover acts as one of the main depositing media in which there is accumulation of heavy metals coming in with atmospheric precipitation, deciduous litter, dead parts of plants and so on. Heavy metals are widespread pollutants of the soil environment. The main accumulation occurs in the upper humus horizons. Contaminated soil acts as the secondary source of the pollution of surface and groundwater, the surface layer of air. The danger of these elements is manifested in the fact that they are able to accumulate in the cells of living organisms, to be included in the cycle of metabolism, to form highly toxic organometallic compounds, to change the forms of location during the transition from one natural environment to another without being subjected to biodegradation. They also affect the abundance, species composition and vital activity of soil microorganisms. Decreasing the rate of mineralization and synthesis of various substances in soils, inhibit the respiration of the soil microbiota, manifest as a mutagenic factor [9].

There is a scale according to the degree of toxic danger of these elements for plants under their increased concentration in accordance with GOST 17.4.1.02-83 (high, moderate and low hazard) [10]:

I class - mercury, arsenic, cadmium, lead, zinc; II - chromium, cobalt, molybdenum, nickel, copper; III - vanadium, manganese.

The general, chemical contamination of the soil cover is described by the gross content of heavy metals, and the availability of elements for plants is determined by their mobile forms. Contamination with mobile forms of heavy

metals is the most dangerous phenomenon, because in this form they can be assimilated by plants and, as a consequence, falls into trophic chains.

The results of the assessment of the heavy metal content in mobile form for the Gryazovets cedar grove are presented in Table 1.

Table 1 - The content of heavy metals in mobile form in the Gryazovets grove

№	Name of the element	Units	Characteristic values		
			During testing	Errors	Norm
1	Manganese	mg / kg	7,59	± 1,3	not more than 300
2	Copper	mg / kg	0,96	± 0,31	not more than 3,0
3	Nickel	mg / kg	0,77	± 0,25	not more than 4,0
4	Cobalt	mg / kg	0,225	± 0,06	not more than 5,0
5	Lead	mg / kg	1,27	± 0,34	not more than 6,0
6	Fluorine	mg / kg	1,71	± 0,30	not more than 2,8

Table 2 presents the results of the assessment of heavy metals content in mobile forms found in soil samples that were selected from the Chagrino cedar grove.

Table 2 - The content of heavy metals in mobile form in the Chagrino grove

№	Name of the element	Units	Characteristic values		
			During testing	Errors	Norm
1	Manganese	mg / kg	7,39	± 0,86	not more than 300
2	Copper	mg / kg	0,835	± 0,17	not more than 3,0
3	Nickel	mg / kg	0,525	± 0,08	not more than 4,0
4	Cobalt	mg / kg	0,145	± 0,03	not more than 5,0
5	Lead	mg / kg	2,785	± 0,29	not more than 6,0
6	Fluorine	mg / kg	1,24	± 0,30	not more than 2,8

Gross forms of heavy metals are the potential reserve of mobile elements actively participating in the biological cycle. They determine the general contamination of the soil cover, but the degree of availability of elements for plants is not reflected.

The results of the assessment of heavy metals content in gross forms for the Gryazovets cedar grove are presented in Table 3.

Table 3 - The content of heavy metals in gross form in the Gryazovets grove

№	Name of the element	Units	Characteristic values		
			During testing	Errors	Norm
1	Molybdenum (in air-dry condition)	mg / kg	0,315	± 0,04	-
2	Mercury (in air-dry condition)	mg / kg	0,046	± 0,005	not more than 2.1
3	Lead (in air-dry condition)	mg / kg	13,75	± 3,4	not more than 32
4	Chromium (in air-dry condition)	mg / kg	8,95	± 3,3	-
5	Manganese (in air-dry condition)	mg / kg	419	± 92,9	not more than 1500
6	Arsenic (in air-dry condition)	mg / kg	1,275	± 0,17	not more than 2
7	Copper (in air-dry condition)	mg / kg	13,1	± 3,1	not more than 66
8	Cobalt (in air-dry condition)	mg / kg	11,75	± 3,6	-

9	Zinc (in air-dry condition)	mg / kg	48,05	± 17,0	not more than 110

Table 4 presents the results of the assessment of heavy metals content in gross forms found in soil samples collected from the Chagrino cedar grove.

Table 4 - The content of heavy metals in gross form in the Chagrino grove

№	Name of the element	Units	Characteristic values		
			During testing	Errors	Norm
1	Molybdenum (in air-dry condition)	mg / kg	0,30	±0,05	-
2	Mercury (in air-dry condition)	mg / kg	0,0575	±0,017	not more than 2.1
3	Lead (in air-dry condition)	mg / kg	20,05	±2,9	not more than 32
4	Chromium (in air-dry condition)	mg / kg	10,95	± 4,6	-
5	Manganese (in air-dry condition)	mg / kg	369,0	±83,5	not more than 1500
6	Arsenic (in air-dry condition)	mg / kg	1,065	±0,15	not more than 2
7	Copper (in air-dry condition)	mg / kg	12,4	±2,6	not more than 66
8	Cobalt (in air-dry condition)	mg / kg	10,45	±3,2	-
9	Zinc (in air-dry condition)	mg / kg	49,3	±13,9	not more than 110

The assessment of the degree of chemical contamination of the Chagrino and Gryazovets cedar groves soils was carried out with the help of sanitary and hygienic rationing of the content of heavy metals (Mg, Cu, Ni, Co, Pb, P, Cr, As, Zn) in the soil-vegetation cover by correlating the actually determined concentration of elements with the maximum permissible concentration (MPC).

For the conventional designation of the units of maximum permissible concentrations, mg/kg is taken, which shows how many times the content of the investigated element exceeds the allowable concentration (values <1 indicate exceeding the MPC, all that> 1 are within the norm).

The mobile forms of heavy metals: manganese, copper, nickel, cobalt, lead and fluorine in the soil samples of the Gryazovets cedar grove do not exceed the permissible concentrations (the average value for the elements is 0.3 MPC). In the Chagrino cedar grove, the values also do not exceed permissible concentrations; the average value for the elements is 0.21 MPC (Figure 1).

The results of analysis of the gross (acid-soluble) content of heavy metals in the soil samples of Gryazovets and Chagrino cedar groves have shown that the numerical values of the elements (molybdenum, mercury, lead, chromium, manganese, arsenic, copper, cobalt and zinc) do not exceed permissible concentrations. The average value for elements in the soil samples of the Gryazovets grove is 0.32 MPC, in Chagrino - 0.33 MPC.

Numerous populations and groups of populations of different soil microorganisms that differ in their ecological functions and taxonomic position are generalized by the term "soil biota". Among them there are bacteria, actinomycetes, microscopic fungi and close to these groups living things.

Many microorganisms contained in the soil are phytopathogens. Fungi of the genus Verticillium, Fusarium and Rhizoctonia belong to the phytopathogenic fungi dangerous for trees [11].

The fluctuations in the number of soil microorganisms (soil biogenic index) are observed not only during the year, but also at relatively short intervals; the impact provide by temperature, humidity, the phase of plant development, the introduction of organic litter in the soil, the accumulation of microbial metabolites, and so on [12]. Soil microflora is under the direct and powerful impact of leaf litter. Leaf litter is the main source of nutrients and microflora washed into the soil [13].

Direct methods of microscopy are used to identify, study and account the number of soil microorganisms.

In the studied samples the number of bacteria is close to each other, in Chagrino cedar grove the number is 11.2 + 1.2 billion/g, in Gryazovets grove - 12.95 + 1.3 billion/g.

The number of actinomycetes has also close values, in Chagrino cedar grove this indicator is 252.1 + 25.0 m/g, and in Gryazovets - 276.75 + 21.5 m/g. Actinomycetes form active substances (antibiotics) that inhibit the development of pathogens on the roots of tree plantations.

The numerical values of mycelium and spores of fungi in the Chagrino cedar grove are lower than in Gryazovets grove. The number of fungal mycelia in the Chagrino grove is 177.4 15 m/g, which is 1.7 times less than in Gryazovets grove (303.25 + 50 m/g), the fungal spore in the Chagrino grove is 2.3 times less than in Gryazovets, in the first value is 40.1 + 5.0 m/g, and in the second - 95.7 +14.0 m/g.

The total quantitative content of microorganisms in soil samples of studied cedar groves is shown in Figure 1.

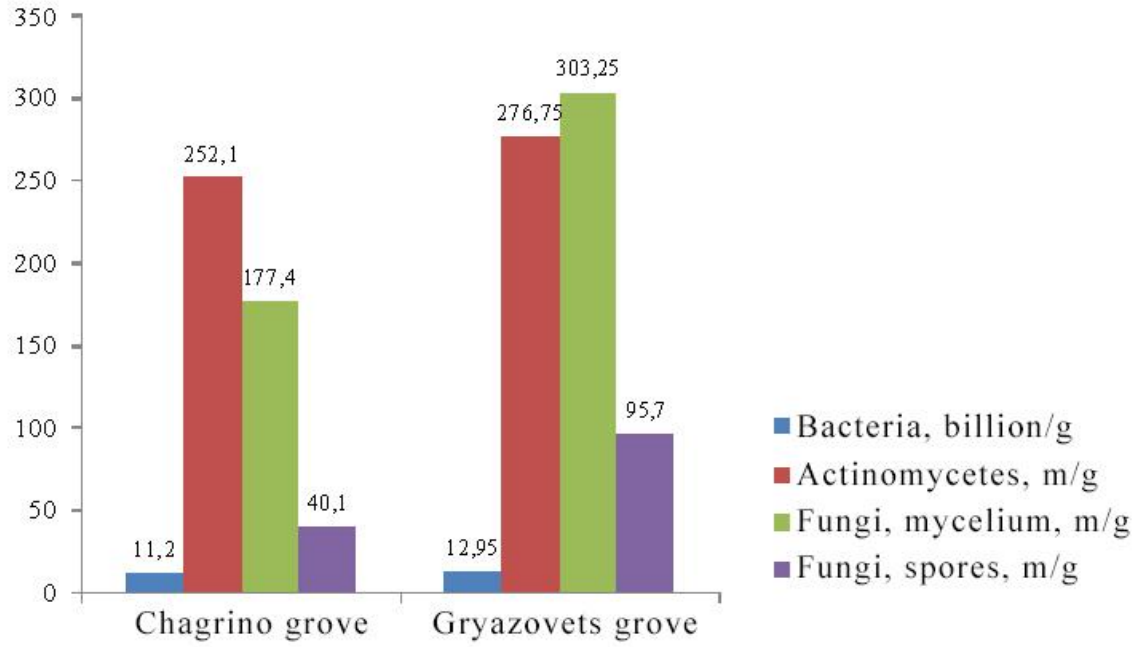

Figure 1 - Total quantitative content of microorganisms in samples

CONCLUSION

In the results of the analysis of microbiological parameters of the soil cover in the cedar groves of the Gryazovets district (Gryazovets, Chagrino village), the following conclusions can be drawn.

According to the taxation indicators (quantitative and qualitative characteristics of cedar plantings), it was revealed that both urban and parked plantations of Siberian pine in Gryazovets and outside the urban environment - in the village of Chagrino are characterized by good growth. Good illumination of crowns, achieved by a rare planting, contributed to their development and increase in the diameter of the trunk.

According to the results of the sanitary assessment, the largest part of the cedar plantations (43% and 49%) in the investigated groves is referred to the second class (weakened). Tree plantations of the II class of the state are completely viable, the probability of their death is not determined; there is no reason to expect the trees to dry out in the near future.

According to the parameters of agrochemical analysis, soil samples have the moderate content of the basic elements of mineral nutrition (phosphorus, potassium, calcium and magnesium), the hydrogen index is 5.2 in the Chagrino cedar grove and 5.1 in the Gryazovets grove, and the degree of saturation with organic matter is estimated on average as 4.87%.

According to the content of heavy metals in soil samples, as among the moving forms of metals: manganese, copper, nickel, cobalt, lead and fluorine, and among the gross metals: molybdenum, mercury, lead, chromium, manganese, arsenic, copper, cobalt and zinc, the exceeding of maximum permissible concentrations in the Chagrino and Gryazovets groves are not observed.

During determining the number of microorganisms in the soil samples of the Chagrino and Gryazovets cedar groves using the method of luminescent microscopy, it was revealed: the number of bacteria and actinomycetes is close to each other, and the numerical values of mycelia and spores of fungi in the Chagrino cedar grove are lower than in Gryazovets grove. The number of fungal mycelia in the Chagrino grove is 177.4 15 m/g, which is 1.7 times less than

in Gryazovets grove (303.25 + 50 m/g), the fungal spore in the Chagrino grove is 2.3 times less than in Gryazovets, in the first value is 40.1 + 5.0 m/g, in the second - 95.7 +14.0 m/g.

Carrying out studies of microbiological parameters of soils in cedar groves is one of the ways to achieve sustainable development of the investigated objects, the growth of healthy cedar plantations; it is aimed at improving the ecological situation in the Gryazovets district.

These studies are necessary to maintain the sanitary and hygienic characteristics of cedar groves, to preserve valuable tree species, to model and develop environmental protection measures.

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