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MORPHOMETRIC PARAMETERS OF A PINUS SYLVESTRIS L. IN CONDITIONS OF LONG-TERM OIL POLLUTION

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In this article the problems of assessment of a vital state of Pinus sylvestris L. in a residential suburb of the settlement Kedrovy in Krasnoyarsk region are considered. Main morphological indicators of annual linear gain like the length of axial shoot's increase, its diameter, quantity and length of needles were selected as key parameters. The change of axial shoot's growth, its diameter, quantity and length of needles under the influence of oil products are noted.

Keywords: Pinus sylvestris L., morphometric parameters, influence of oil products, annual linear gain.

Conference participants

Constantly increasing pollution of environment by oil products causes concern in the world community. Mainly water and soil cover are polluted. Their condition draws attention of scientists and public. Complex chemical composition of oil and oil products causes a number of environmental problems, connected with the change of biological and microbiological properties of water and soil, as well as big damage of flora and fauna. In particular in soil increases the content of heavy metals, which are the part of oil (Pb, V, As, Ni); their content is more than maximum permissible concentration (MPC). Heavy metals negatively affect plants, slow down their development, reduce the general maintenance of microorganisms, and, what is most important, slow down the effect of more than 15 enzymes, which are contained in a human body [Davydova, 2002].

For assessment of consequences of technogenesis it is necessary to reveal indicators, adequately displaying the state of environment. As for biological methods, a bioindication method is considered to be a priority one by many authors [Artamonov, 1986; Sergeychik, 1997; Spiridonov, Zverev, 2005; Neverova, Yeremeyeva, 2006; Soboleva 2009]. Plants are the most suitable for assessment of a state of environment, as they carry out more intensive gas exchange in comparison with human beings and animals, possess higher sensitivity and stability of response to influence of various external factors [Sergeychik, 1984].

Pinus sylvestris L. is used as a bioindicator in the process of assessment of a state of environment by many scientists. It is well-known that Pinus sylvestris L. is a species, reacting to habitat pollution by technogenesis products [Kovylina, Zarubina, Kovylin, 2008]. This phytometer is widely spread on the whole territory of Krasnoyarsk region; it grows both on dry sand and in conditions of superfluous humidity. In this regard Pinus sylvestris L. is a suitable object for bioindication of the pollution level in any area of Krasnoyarsk region.

Reactions of Pinus sylvestris L. to the existence of polluting substances in the air and in the soil are not specific and reflect the general level of pollution of the environment by chemicals of various provenances. Different signs of a phytometer are used for the assessment of chemical influence on it. A morphological approach is the most widespread and easy to use [Zaharov etc., 2000].The size of annual increase of a main shoot, the length of a leaf, the size of genesic organs are recommended to be used as indicative signs in various references [Selyankina, Shkarlet, Mamayev, 1972; Popovichev, 1980]. Yearly linear gain of wood plants is offered to be used as an indicator of monitoring of consequences of anthropogenic impact on environment [Kuhta, 2003]

Needles condition is an informative sign of a certain level of pollution of the atmosphere. It includes coloring change (chlorosis, yellowing), premature withering of needles and defoliation, life time, existence of necrotic spots [Alexeev, 1990]. Thus the form and color of a necrotic spot is a specific reaction to a certain type of pollution, and the share of the struck surface of a needle can be used for a quantitative assessment of reaction of the phytometer. Morphological and anatomic characteristics of pine's needles can also be used for the indicative purposes.

The needles of a pine are also used as a bioaccumulator of aerogenic pollution [Schubert, 1982, Chernenkova, 1986]. It is connected with the ability of pine's needles to effectively absorb polluting substances, in particular, compounds of metals in the form of aerosols at the expense of their diffusive sedimentation in cavities and air channels of a leaf [Fomin etc., 1992]. Also a pine possesses bioaccumulative ability for a number of metals, whose compounds are absorbed by root system from the soil. Absorption can be both metabolic and passive [Kabata-Pendias, Pendias, 1989]. Carrying out the absorbed microelements from a pine's leaf surface at evaporation of moisture and gas exchange with the atmosphere is very small because of a small surface of a leaf, incrassate skin and a small amount of stomata. During needles life (4-6 years depending on conditions of a tree growth) microelements typical for this district are collected in its mass in quantities, sufficient for analytical definition.

Thus now a pine as a bioindicator is studied mainly for the definition of aerogenic pollution. We made an attempt to use a pine as an indicator of oil pollution of soils.

A derelict black oil boiler room of a small town of the 36th rocket division of rocket strategic forces liquidated in 2003 was chosen as the object of research. A black oil boiler room, further in the text – the object of researches - is situated in the northeast suburb of the settlement Kedrovy (latitude is 56°13¢58², longitude is 92°20¢35², height above sea level is 278 meters), of Emelyanovsky area, Krasnoyarsk region.

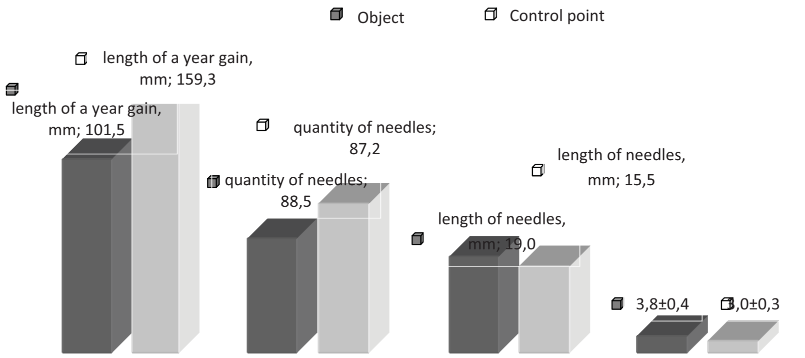
The object of research is a black oil trap of a black oil boiler room taken out of service, on whose territory there are two capacities for storage of black oil for five thousand tons each. A black oil trap with the area of 5000 sq.m is filled with black oil on the area of about 2000 sq.m.

The only wood form directly adjoining the oily pollution is Pinus sylvestris L., which became the object of research.

Morphological indicators of annual linear gain [Fedorova, Nikolskaya, 2001] such as the length of annual gain, the quantity of axial shoot's needle, the length of needle, the diameter of an axial shoot were chosen as key parameters of assessment.

For the realization of the intended objective the study of Pinus sylvestris L. was conducted in the field period of 2009. The study was made on two study plots (20x25 m) laid out at a distance of 500 m. from each other and differing in the level of anthropogenic influence according to standard practice. Ten trees were investigated on each study plot. The first study plot was laid out on the object of research, the second is a control point laid out in the same settlement and in the same environmental conditions (composition of the soil, luminance, etc.) but without influence of oil products.

The mean values of morphometric indicators were determined at laboratorial inspection of data. All materials were processed statistically according to standard practice [Pavlov, Smolyanov, Weiss, 2005].



Pic. 1. Average morphometric values of P. sylvestris L. on the territory of the object of research at the beginning of the vegetative period

The research of morphometric parameters of P. sylvestris L. at the beginning of the vegetative period demonstrated, that average length of yearly increase (of the first and the second order) of the trees influenced by oil products was 37 % less than in a control point, which is probably connected with the deterioration of a vital condition of a pine owing to the influence of petrohydrocarbons (pic. 1).

Thus, reduction of quantity of needles on the increase of trees of the object wasn't so considerable and statistically doubtful (P≥0,95) – only 9% . Calculation of the ratio "quantity of needles/length of increase" demonstrated their denser arrangement on a stalk. The needles of trees of the object were 22, 6 % longer than those in the control point. This indicator is very interesting, as at aerogenic pollution the length of needles in control points is usually bigger. The combination of such changes can testify to low extent of anthropogenic impact on plants.

The diameter of an axial shoot of the object is 21 % bigger than that in the control point. Therefore, at the impact of oil products on a pine, its growth increases not in length, but in thickness.

To compare the samples it is possible to introduce the reduction coefficient of growth functions of tested plants organs with respect to control ones. [Stupko, 2009]:

$$K_{red} = (K_l + K_n + K_{lb} + K_d)/4,$$

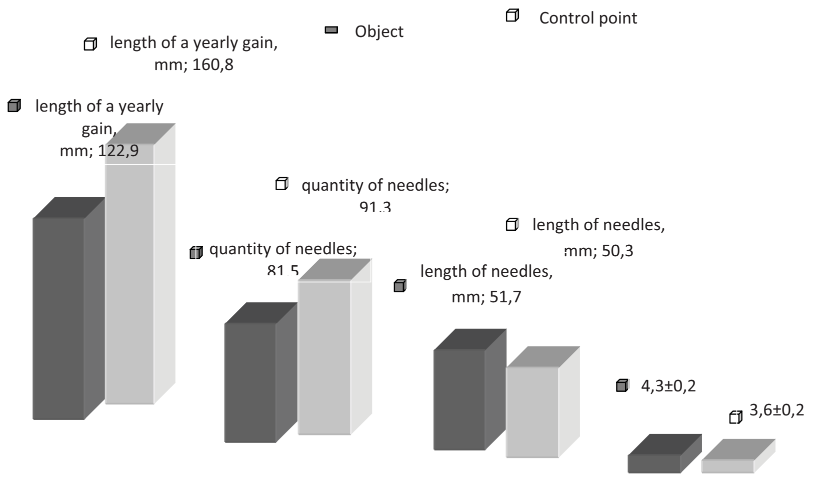
where K_l (the length of yearly increase), K_n (the quantity of needles), K_{lb} (the length of needles), K_d (the diameter of an axial shoot) are particular reduction coefficients equal to the relation of an average value of an indicator in stressful conditions to its average value in control ones. The higher this coefficient is, the more stable the object is.

K_{red} of pine at the beginning of the vegetative period was 1, 01.

When studying morphometric indicators of a pine in dynamics at the end of the vegetative period (pic. 2), the same indicators were measured.

The average length of shoots of yearly increase of a pine on the object of research was 24 % less than in the control point.

The quantity of needles of yearly increase of an axial shoot on the object of research was 11 % less than in the control point. The quantity of needles per 10 cm of a stalk length turns out to be 66, 3 on the object and 56, 8 in the control point at recalculation. Thus, the density of needles of a pine influenced by oil products remained higher though



Pic. 2. Average morphometric values of P. sylvestris L. on the territory of the object of research at the end of the vegetative period.

decreased at the expense of greater axial growth.

It should be noted that a pine on the object of research had a longer period of axial growth. Thus during research period the gain of an axial shoot was 21, 0 % while that of control plants increased as much as possible already by the beginning of the account and practically didn't change for the next period.

The length of needles on the object of research is 3 % more than in the control point. Thus, by the end of the vegetative period the difference of length of needles became insignificant.

The diameter of an axial stalk at the end of the vegetative period kept a 16 % bigger size on the object of researches.

K_{red} of a pine at the end of the vegetative period was 0, 97.

Besides supervision over yearly linear increase of a pine in the vegetative season its aging and damages of needles was observed which showed that the pine on the object of research grows older on a three-year yearly increase and has higher share of damaged needles – 11, 6 %, while in the control point this share was only 3,4 %.

Analyzing the aforesaid, it is possible to note that in conditions of spill of fuel oil in a researched trap the extent of impact of pollution on a pine is estimated rather as an average one because a number of researched morphometric parameters of the vegetative sphere of plants submitted to chronic influence exceed the control ones. It can testify to the possibility of compensation of harmful effects of this type of pollution at the expense of adaptable mechanisms of a Pinus sylvestris L.

It is not excluded that oil products influence plants to some extent, actively evaporating from a flood surface, however the mechanism of this influence isn't studied yet.

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