On the implementation of the ecological approach in the process of territories demilitarization

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Abstract. Ensuring environmental safety in the areas of rocketry operation is associated with an assessment of the natural environment response to the transient effects of chemically hazardous substances. The object of the research was Scotch pine as a bioindicator of pollution of the soil from the storage area of rocket fuel components (RFC). Infection of the needles with chlorosis and necrosis can characterize the level of soil pollution with toxic components. For soil reclamation, it is recommended to carry out a microbiological analysis of the soil and make a detailed map of phytotoxicity to calculate the volume and technology of work. When making a phytotoxicity map, it is recommended to take into account the percentage and quality ratio of needles samples subject to necrosis and chlorosis.

1. Introduction

The problem of reclamation of ground areas contaminated with rocket fuel components (RFC) due to the location of rocketry becomes especially acute if these areas are subsequently intended for use in the agricultural sector [1]. The complex chemical composition of rocket fuel components (RFC) is the reason of environmental problems associated with changes in the microbiological properties of soil and water and with damage to the plant and animal world [2-3]. Most propellant components are very toxic, and their release into the environment is accompanied by soil and air poisoning in the propellant spillage areas [4-5].

Plants are most suitable for assessing the state of the environment since their gas exchange is more intensive and their sensitivity is higher than those of humans and animals; besides, they are more stable in response to the action of various external factors [10].

To assess the effects of technogenesis it is necessary to identify indicators that adequately reflect the state of the environment. The percentage ratio of needles samples infected by necrosis and chlorosis from the areas of possible spillage of RFC to the total number of needles under study can serve as such an indicator.

While studying the state of the environment many scientists use Scotch pine (Pinus sylvestris L.) as a bioindicator, as it is a species that responds to environmental pollution with products of technogenesis [11]. This phytointegrator is widely spread throughout the territory of the Krasnoyarsk Krai; it grows both on dry sands and in conditions of excessive humidity. In this regard, Scotch pine can serve as a suitable bioindicator of pollution levels in any region of the Krasnoyarsk Krai.
Thus, at present Scotch pine (Pinus sylvestris L) as a bioindicator is being studied mainly for the determination of airborne pollution. We have attempted to use Scotch pine as an indicator of soil contaminated with RFC [12].

2. Area, object and methods of research
The area of research includes the village of Kedrovy (Krasnoyarsk Krai, Russia) where rocket fuel components of one of the reduced rocket divisions of the strategic rocket forces were stored, and the adjacent areas. The storage area is a plot of 7000 m² where the structures typical for these facilities are located: structure № 1 is ADMH (asymmetric dimethyl hydrazine) storage; structure № 2 is a cleaning station; structure № 3 is a neutralization station; structure № 4 is an oxidizer storage; structure № 5 is a laboratory. (figure 1) For the delivery of rocket fuel components there is a railway line as well as technological platforms for parking of tankers [13].

It was established that radiation levels (exposure and equivalent doses of external gamma radiation, levels of alpha and beta fields, specific activity of radionuclides, including technogenic cesium-137) in the study area correspond to background indicators. According to the testimony of a military chemical reconnaissance device (MCRD), the content of RFC on separate sample areas is 0.001 mg / l, which corresponds to the “Danger” level. There are visible traces of spills of technical fluids on the soil in special structures, and in the air there is a specific smell. Chemically contaminated fittings, construction debris, remnants of containers and special structures are in an abandoned state. Researches were conducted on the ground with the purpose of subsequent soil reclamation and soil cleaning from residues of RFC spillage. As of 2015, the concentration of ADMH inside the structures exceeded the MPC by 50 times and in the adjacent territory by 10 times [7]. On the territory of the former missile unit there are abandoned structures in an emergency condition [8].

Scotch pine (Pinus sylvestris L) is the most common tree species located in the studied areas close to the zones of possible propellant spillage areas. It has become the object of research [14]. In order to realize the goals set in August 2016 samples of needles (shoots of 2016 and 2015) were collected in areas close to the places of the proposed RFC spillage areas. Samples were taken from trees at each of nine grounds with an area of 10 x 10 meters, at a distance of about 50 meters from each other. The control ground is located five kilometers from the object of study [15]. The location of the grounds is shown in the diagram (figure 1).

The vital status of Scotch pine crops in the suburban area of Kedrovy village of Krasnoyarsk Krai was assessed. The infection of needles samples with necrosis and chlorosis were chosen as the main parameters (figure 2). A change in the color of the leaves or needles is in most cases a non-specific response to various stressors.
The counting of the affected samples of collected needles was made with the help of visual inspection for shoots of 2015 and 2016 [9].

Classes of chlorosis: 1 - needle without spots; 2 - some small spots; 3 - many yellow and brown spots, sometimes throughout the width of the needle. Drying classes: I - no dry areas; II - shrunk tips of the needles; III - dried third part of the needle; IV - the whole needle is yellow and half dry

The relative position of each tree on the ground and its morphological indicators are presented in table 1.

**Table 1. The position of the studied trees on the ground.**

| № of the ground | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   |
|-----------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Distance to the nearest building (m) | 1-2 | 17  | 24  | 60-63 | 30-33 | 20-26,5 | 47-55 | 70-71,5 |
| Distance to the neighboring building (m) | 20-21 | 14  | 50-55 | 10-12 | 50-52 | 10-13,5 | 2-4 | 0 |
| Distance to the road (m) | 1-2 | 2   | 1-1,5 | 10-14 | 10-12 | 7-10 | 15-16,5 | 43,5-50 |

Average values of morphometric parameters were determined during the office data processing. All materials are processed statistically according to the generally accepted methodology [16].

3. **Research results**

After the liquidation of the military unit, an unfavorable environmental situation arose due to the uncontrolled spillage of RFC. The study of the morphometric parameters of Pinus sylvestris L. showed that the maximum susceptibility to chlorosis and necrosis was detected on samples of grounds № 3,4,6,8. The average damage indicators of various classes are presented in diagrams (figure 3, 4).
The chi-square test was used to determine the static significance of the difference between test samples and samples from the control ground [17].

A statistically significant (from $p = 0.05$ to $p < 0.001$) damage to the needles of the object of research with respect to the control was noted in all areas. At the same time, there is a statistically significant ($p < 0.001$) geographical irregularity in phytotoxicity (figure 3).

Thus, it can be stated that the residual chemical pollution on the object under study is clearly uneven. At the same time, the unevenness of pollution is only partially connected with location of a specific structure. This fact suggests that during the dismantling of the equipment there was accidental spillage of RFC. In this regard, it should be recommended to carry out a set of measures for the reclamation of the area without reference to specific structures. When working on the detoxification and rehabilitation of the soil, it is necessary to take into account the pronounced spatial unevenness of the level of residual pollution.
Figure 5. Map of phytotoxicity of the soil on the object under study (numbers on the vertical axis show % of affected needles relative to the control, the horizontal axis shows the distance from the extreme south-western point of the ground).

To calculate the volume and technology of work, it is recommended to carry out a microbiological analysis of the soil and make a detailed map of phytotoxicity. When making the phytotoxicity map, it is recommended to take into account such a set of indicators as the percentage and quality ratio of needles samples subject to necrosis and chlorosis.

4. Conclusion
An unfavorable ecological situation developed after the liquidation of the military unit in the village of Kedrovoy of Krasnoyarsk Krai due to the ingress of a significant amount of RFC into the soil. It was reflected in the morphological indicators of Scotch pine (Pinus sylvestris L).

On the territory there were special facilities, construction debris, remnants of tanks, and fuel fittings with chemical contaminants. In this regard, the reclamation of the area is required.

When working on the detoxification and rehabilitation of the soil, it is necessary to take into account the pronounced spatial unevenness of the level of residual pollution.

To calculate the volume and technology of work, it is recommended to carry out a microbiological analysis of the soil and make a detailed map of phytotoxicity.

Taking into account the possible migration of ADMH, chemical monitoring of adjacent territories and rivers should be carried out.

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