ENVIRONMENTAL SAFETY OF CONSTRUCTION AND MUNICIPAL SERVICES

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MONITORING FOREST ECOSYSTEMS IN THE INFLUENCE ZONE OF HIGHWAYS

Statement of the problem. These days we cannot do without evaluating the effect the highway construction has on the environment. The influence of highways on forests is hard to evaluate in experiments or modeling, therefore obtaining credible information on changes occurring in forests under the influence of highways is possible provided there is ongoing observation (monitoring).
Results. Based on experimental studies, a complex approach to studying the influence of highways on soil and plant environments of near-highway strips was set forth. The observation was carried out on plants that are a critical component of the biosphere and snow cover as well. Plants are crucial to determining the influence and snow cover is crucial to determining its scope.
Conclusions. The suggested method of creating a system of constant observation site that is part of more complex, "key" areas with further systematic and complex observation allows for an objective evaluation of the influences of the road and transport complex on a degree of contamination of ecosystems of near-highway strips, also to forecast scopes of environmentally challenged near-highway areas and to perform environmental regulation of the effect transport has on forests.

Keywords: a near-highway strip, forest ecosystems, natural observations (monitoring), transport pollution, environmental regulation.

Introduction

The interaction of the road transportation infrastructure with the environment is currently one of the components of the global environmental problems. The global environmental crisis raised the awareness of the "growth limits" in many of the fields. It is strongly experienced in the construction and operation of highways. Degradation of land used for the building of infrastructure, landscape transformation, traffic problems, road accidents, traffic noises, pollution of the lithosphere, atmosphere and hydrosphere are major problems currently faced all across the country.

The problem of "green growth" is now a major focus worldwide, which involves economy growth owing to the use of modern, environmentally viable and energy-saving solutions, coherent procedures documented in accordance with the International Standards ИСО 14001, ИСО 0991 and other relevant international standards. Not all the principles of the international environmental management are complied with in the Russian Federation — the Russian nature conservation law is exclusively compensatory, i. e. it capitalizes on the restraining and forbidding guidelines and administrative and criminal liability and fails to promote the standards to see through the improvement plans.

The pressing issue is that in Russia there is no legislation in place as well as environmental audit and monitoring of the road industry. Russia is generally 20 or 25 years behind in its environmental and hygienic research. Environmental testing of road projects is now not deemed obligatory and is supported by Glasgosexpertisa and does not have any impact whatsoever on the way a project is implemented and is confined to nature conservation areas. Therefore Russia has some decisions to make concerning environmental damage in the process of the construction of linear objects and technological development of the transport industry overall.

Russian road transport infrastructure should evolve and prioritize on the environmental approach, since the environmental stability approach in the long term is seen as central to the viability of any project as well as the construction and operation of roads. Therefore the strategic purpose behind the road transportation complex should be to preserve natural systems, maintain their living functions in order to secure sustainable development of the society thus promoting health and birth rate and delivering on environmental safety of the country.

The existing road industry guidelines take no regard for the need for identifying the protection carriageways in the vicinity to the roads where the design population level is beyond the health and safety requirements. However, the modern practices suggest that areas with a developed transport infrastructure are at a higher risk of environmental disasters with a 10 or

15 fold increase in the critical and acceptable level of loads for different components [1]. Therefore road highways should be constructed, operated and maintained with (except for legal right-of-ways and parkways) with the sizes of these areas in mind.

Forest ecosystems are dynamic and it is normally not natural but artificial (anthropogenic) factors that contribute to this change: industrial and transport pollutions, etc. There is a whole range of pollutants that find their way into the forests adjacent to highways. They are carbon and nitrogen oxides (so-called nitrous gases), non-saturated hydrogen, carbohydrates, bens (a) piren, smoke black, dust and heavy metal impurities of such as Pb, Cu, Cd and Zn classified by the GOST to be the first and second hazardous class and assessing damages to forest ecosystems caused by certain components of pollutants is a costly and timely undertaking.

A promising way of launching a study into the effect road highways have on forest ecosystems and the sizes of environmentally underprivileged parkways is a natural observation on transects constructed from the body of the highway deep down into the massive including the gradients of all factors coming into play (landscape conditions, vegetation and soil, traffic, etc.) where methods of forest study, geobotany and soil study can be employed.

The main subjects of this observation are vegetation which is a major biosphere contributor and its general condition as well as snow cover which is somewhat of a marker that is indicative of toxicology along the road. The study of the chemical makeup of snow is advantageous in some manner – the season snow cover keeps the information of the substances that come in with precipitation or as a result of aerosol precipitation over the entire cold season. Therefore the analysis of the concentration of chemical elements and alloys contained in the snow is ultimately consistent with their amount in the atmosphere of the region of interest.

1. Object and method of the research

The experimental research relied on the complex approach to the study of the effect highways have on soil and vegetation of the parkway. The main subject of the research was the parkway of the M-4 Don highway.

Representation of the observations of the traffic flows, plan and longitudinal profile of the highway, landscaping of the adjacent area were critical to the choice of the gate. A number of the toll gates were outside large residential areas which enabled us to establish the pure effect of highways and put together the data on extended areas along the highways. In the highway area of interest we examined the content and intensity of a traffic flow and the characteristics of soil, vegetation and snow cover were also identified [2].

Snow was selected at 4 transects using the conventional methods in the three-dimensional repetition. Transects (observation gates 7, 8, 9, 10) were placed perpendicular to the road, the snow was collected 10, 30, 70, 110, 190 m away from the body of the road. The snow water was pressure filtered twice — first to separate the slurry and second to separate a concentrate of the dissolved heavy metals following their concentration into inside complex alloys by natrium tiooxidant ($C_9H_6NSNa \times 2H_2O$) for a better remediation of heavy metals. This procedure guarantees a 94-96 % impurity outlet [3]. The amount of the slurry was measured on torsion balance weights by the difference in the mass of the dried filter and pure one.

The condition of the stand of trees was evaluated visually on a five scale ranging from a healthy tree to deadwood. The category of state was established according to a range of properties: architecture of the crown, height growth, condition of branches, trunk and roots. Healthier trees were placed higher on the scale which is arguably more consistent with the notion of "a healthy condition of the stand of trees":

1 — *deadwood* is trees that got dry in the current year or previous years; no fur (leaves), the top is commonly broken, the crown and small branches fall off easily, the wood boring beetles are out;

2 — *decaying trees* with a thin (declining) crown or a few fruiting branches (with the decay of a 2/3 of the photosynthetic apparatus), leaves (fur) is turning yellow and falls off, no height increase, possible flush cuts on the trunk and roots and individual fresh habitats of stem beetles;

3 — *trees with high failure potential* with poor or lean architecture (with the decay or drying of a 2/3 of the photosynthetic apparatus), terminal growth loss, dry top, significant damage, failure of trunk and root plates, a local decay might be associated with wood boring beetles;

4 — *weak trees* show a poor architecture (with the failure of 1/3 of the photosynthetic apparatus), terminal growth loss, individual dry branches, failure or death of a trunk part or root plates;

5 — *healthy trees* with no obvious signs of decay, thick green crown, normal growth over the recent years.

Each observed gate was divided into 20-metre squares where the location of each tree was mapped with a record of breeding, height, diameter specifications as of the point of observation.

3. Results of the research

As a result of the research the data was obtained on the snow slurry depending on the distance between the roadway on the four gates of observation (Table).

Table

Snow slurry in snow water
in the gate of observation of 7, 8, 9, 10, mgl^{-1}

Gate of observation \ Distance from the roadway, m	10	30	70	110	190
7	142.8	138.8	94.3	37.4	27.6
8	266.4	157.2	70.3	56.3	29.4
9	176.6	114.4	64.1	58.1	46.3
10	156.2	172.3	131.2	86.0	73.1
Averaged pollution	185.5	144.9	90.0	59.5	44.1

Using the above data (Table 1) a graph of the dependence of the slurry content in the snow on the distance from the roadside (Fig. 1a) was designed and Fig. 1b identifies the map tree that details tree vigor indicators obtained in the gate of observation. Isolines of the tree condition were designed based on the coordinates and overall data on the profile tree condition. This map thus indicates the effect the road has on the overall condition of the stand of trees including the upper and lower forest layers. In the gate of observation the slurry contained in the snow is the “dose” and tree category data is the “effect”.

The tree condition map (Fig. 1b) suggests that a tree vigor declines dramatically in the vicinity to the roadway and higher slurry content respectively. The ecosystems in the immediate vicinity to the roadway are exposed to adverse effects of pollutants which negatively impacts on their hygiene, production and mineralization of organic substances, chemical makeup of vegetation, soil and cover.

a)

b)

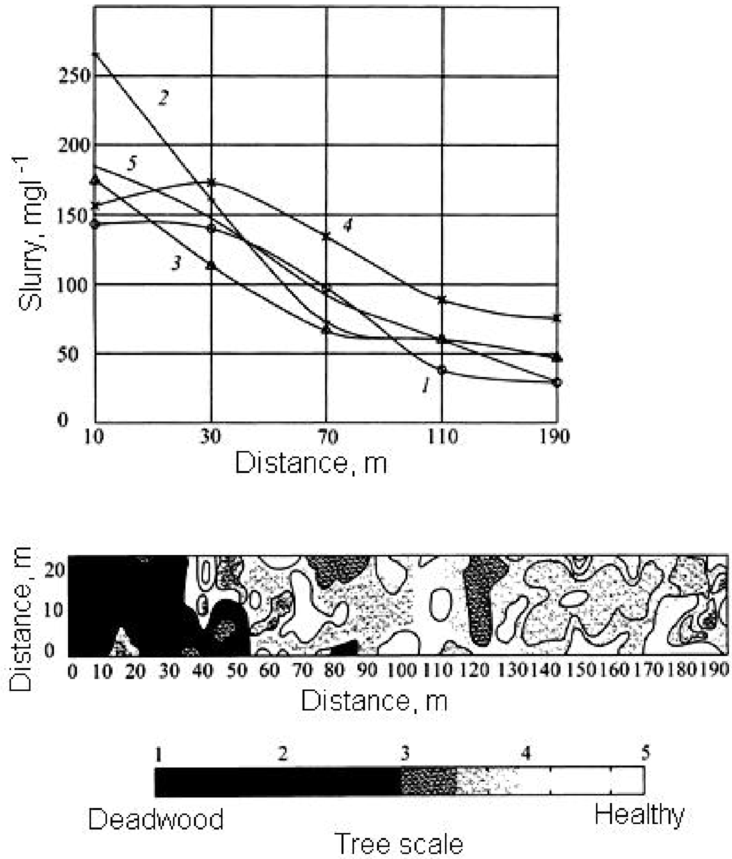

Fig. 1. Graph of the dependence of snow slurry on the distance from the edge of the roadway:
a) 1 — gate of observation 7; 2 — gate of observation 8;
3 — gate of observation 9; 4 — gate of observation 10; 5 — averaged pollution;
b) tree map in the transect in gate of observation 8

The roadside width with lethal decay of tree vegetation is not restricted by the guidelines [4] for the technical zone (12—15 m) and is twice the distance. The first 40—50 m off the roadway are at extreme risk of natural disasters with trees dying at a rapid rate. There are an average of 2 trees falling in this category.

There is a slight drop in vigor indicators starting from 130 m off the roadway which is further accounted for by the landscaping conditions of the forest which is invariably more deteriorating under a greater anthropogenic effect (stimulation effect in small doses).

Based on the data, the graphs of the dependence of the tree category and aerosol content in snow on the distance from the roadway (Fig. 2) were designed that are helpful in determining the dose — i. e. the effect of this ecotope (Fig. 3).

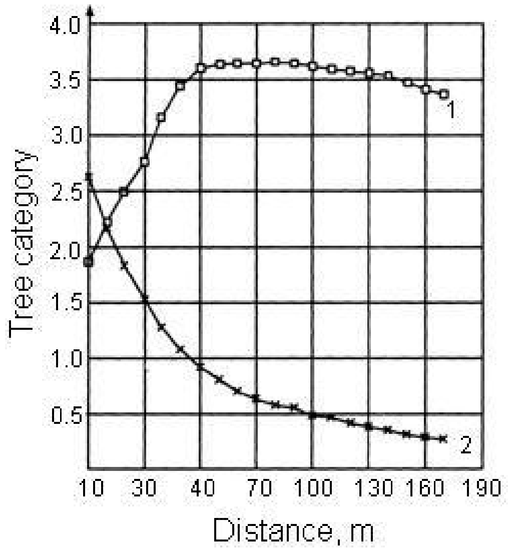

Fig. 2. Dependence of the tree category on the snow slurry and distance from the roadway: 1 — tree category; 2 — snow slurry concentration

The dependence of tree vigor on the snow water slurry (Fig. 3) indicates that snow slurry of over 120 mgl^{-1} results in a dramatic drop in a tree category. The maximum possible amount of slurry in snow is therefore no more than 120 mgl^{-1}. This is the threshold of the toxic effect on the forest of interest exerted by vehicles in these particular conditions.

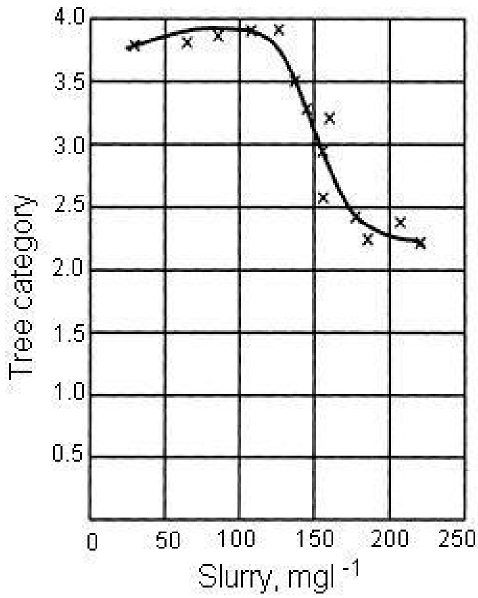

Fig. 3. Dose effect of the dependence of the life condition of deadwood on the snow slurry concentration

In case this threshold is exceeded, construction and organization measures need to be in place: provisions should be made for vehicles to be fitted in with an afterburner, catalysts, for a reduction in traffic intensity, parallel highways to be constructed to cut down the load off the those available; transport bypassing to provide smoothly running traffic flows; the use of noise-insulating partitions from gas-absorbing blocks of sorbent gas materials (with their timely replacement).

Conclusions

The results of the experimental research into the condition of tree landscaping in the roadside are as follows:

– forest ecosystems are in constant dynamics; these changes are due not only to natural but also artificial (anthropogenic) factors: industrial and transport pollutions, heavy recreational loads, etc. There is a growing number of undesirable consequences faced with: forest degradation, their lower stability and aesthetic value, deteriorating biodiversity;
– in order to address ever-increasing environmental issues faced by the road industry fundamentally new approaches need to be in place and relevant methods of monitoring the technology as well as relevant applications of the properties of living organisms since the natural structures are more frail and are rivaled by any engineering effort;
– constant testing grounds for long-term observations are a viable method for multiple credible information on the state of forest systems and their dynamics under the anthropogenic effect; an objective evaluation of travelling conditions as for the time of the pollution of the roadside systems, predicting the size of environmentally underprivileged area depending on particular landscaping conditions, vegetation and soil as well as addressing the environmental effect of the road transport industry on forest systems.

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