DYNAMICS OF INDUSTRIAL-INDUCED LANDSCAPE MODIFICATIONS IN MOTCHE-TUNDRA AND GEOCHEMISTRY OF AREA POLLUTED BY MONCHEGORSK1 NICKEL FACTORY IN 1970 -1990

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Abstract

In 1970 - 1973, we organized ecological monitorin of the northern taiga and tundra landscapes (ecosystems) in impact zone of the Severonickel factory (Kola Peninsula). Repeated observations and dimensions were copmleted in 1973-1990. The study aimed at establishing an area of influence and alterations of landscapes in the impact zone. 

Within 10 - 13 years (1983 - 1987) the observation was repeated. That time we aimed to determine pollutants levels in snow cover, restrict recent area of influence, measure heavy metals levels and pH in soil samples and plants. Landscape survey of territory was repeated in 1986 - 1987. Dynamics of landscape technogenical modifications (for 13 years) and tendency to technogenical alterations in the future were revealed that time.

According to results of geochemical analysis, soil samples from 11 test ground rows of accumulation gush out were investigated in respect to natural background, which was established in 1973. We achieved: one – factorable and analysis for determination influence Cu, Ni, Co levels in snow cover and in soil; two – factorable dispersical analysis pollution influence of snow and pollution of the soil, where landscapes were affected in an influence zone; one – factorable dispersical analysis of an influence of an elementary landscape type (that position in geochemical conjugate) at it stability.

We discussed entropy of plant and natural complex as whole, completed information models of technogenical modifications landscapes, drawn conclusions about an extent of the northforests landscapes stability by impact of the factory factory.

Introduction

Ecological regulations for landscape must be based on assessment of its landscape-geochemical capacity, stability of its components, biotical in the first place, and stability of the landscape as an integral formation. The ecological monitoring must
include not only landscape components (atmosphere, water, soils, plants, animals), but also landscape as the whole, especially various zonal landscape types.

With landscape indices of environmental pollution, not only an analysis of the landscape-genetical rows has a predective significance but also the rows of spatial-temporary technogenic modifications of the landscape, which enable to judge a role played by the variable conditions of the natural complexes. The number of technogenic modifications row at time of their existence characterises the depth of the landscape structure damage. It is important to assess informative value of the landscape morphostructure for predicting its condition under various impacts. It can be revealed during an analysis of the functional disturbance and reconstruction of the dynamical rows, landscape capacity to modification, number of some technogenic modifications, typical time of their duration.

The monitoring of impact zone consisted of stationary and half-stationary observation regime of heavy metals and sulphur compounds, conditions of spreading and distribution of technogenical substance and their inclusion into natural complex. Heavy metals concentrations in the natural complexes have been measured as well as their levels in soils and plants, rivers and lakes, rain water, snow, and air. In the same time, landscape alterations have been recorded (ecosystems), infringement fitocenozes, soils, fauna, invertebrate and microorganisms, and also a condition of landscape morphostructure in general.

The landscape monitoring included observations alteration of geometry zones influence by indications and also observations of dynamic northforests landscapes and technogenical modifications of it and alteration geochemical essence of it. The monitoring result allowed too estimate ecological norm of influence to landscape.

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Organizations participated in research in Monchegorsk test ground in last twenty years. The observation of these researches is the object of special investigation. In this article is realise it is impossibly. We have marked only sectoral disposition of these research and the necessity to perform complex analysis and its generalization. In preparation of materials to the publication participated E. V. Ivanova and I. A.

1 At this point and further the technogenical modification of landscape is appointed degree of it disturbance. (Doncheva, 1978). Moreover the most disturbance state is the last stage its technogenical transformation and correspond to TM-1; from TM-1 to TM-4..., TM-7 etc the disturbance is weaken.
Materials and methods

Explorations are conducted in sphere of „Severonickel“ factory impact at distance to 10 km for latitude and 30 - 40 km for longitude at area near 900 km.

The studies have been carried out in the natural-territorial complexes (northforests and tundras), adjacent to Imandraplake socle plain and large-scale tectonic-denudation massifs (Fig. ) and also their components and elements (soils, plants, snow cover, waters etc.). Vakuable methods of landscape and biological indication, geochemistry of technogenesis, systematic research, landscape-geochemistry and landscape approach have been worked out as well as problems solutions of landscape technogenical modifications (the original state of variable biogeocoenoses) have been described. Methods are discussed earlier (see Abstract).

Test grounds of 50 x 50 were organized for an observation of northforests dynamics in the Severonickel factory impact zone. Observation places have been made at different types of natural complexes and different distance from the factory. Fifty parameters of natural complexes have been fixed on observed grounds.

The plot 80 sq. km was selected for landscapes survey during perennial observation of the natural complexes dynamics. Large scale map containing technogenical modifications of the natural complexes urotshistshe with fixation of the natural hierarchy systems, and at the same functional-dynamic rows of technogenical modifications landscapes.

In 1987, 100 grounds with detailed fix state of natural complex for an investigation of the technogenic impact (especially on plants) have been organized, and landscapes description has been repeated for 130 technogenic landscape modifications revealed in 1970 - 1973. In soil (200 samples) the following parameters have been defined: aqueous extract composition, pH, absorbing complex, total content of 40 elements, especially Ni, Cu, Co, Cd, Pb, Zn, Fe, Al, Mn. These elements were assayed also in soil aqueous and HCl extracts.

Results

In 1970 - 1973, we tried to calculate the maximum permissible waste of „Severonickel“ for the landscape of the northern taiga. A purpose of the work was to estimate wastes flow into the landscape and simultaneously to determine wastes or their components accumulation in the environment as well as landscape status. Complex of work for defining the critical loads of the „Severonickel“ factory on the northern taiga landscape consisted of an observation of wastes regime, heavy matals and sulfide compounds, conditions of technogenic matter spreading and redistribution, an inflow of the factory wastes into a landscape.

At the same time, heavy metals levels in soils and plants, river waters and lakes, rain water, snow, and the air have been assayed, changes in landscape elements and
components were registered (disturbance of phytocenosis, soil, fauna of invertebrates and microorganisms and also the condition of the landscape morphostructure as the whole; Doncheva, 1978).

The maximum permissible wastes inflow into the environment as determined according to the decrease in waste components levels in atmosphere, water, soils, plants, taken from regression curves, also disturbance curves of biota of the landscapes (according to the number and biomass of the ground soils invertebrates, microorganisms, plants), as well as disturbance curves of the vertical and horizontal structure of the landscapes. These curves were used to determine mean value of wastes inflow, inherent in the territories with undisturbed biota. This mean was accepted as a maximum permissible one. While estimating the standards, a character, time and intensity of mechanical and biogenic migration of wastes must be taken into account as well as non-linear dependance of the waste accumulation in the landscape elements at the distance from the pollutio source, and uneven character of the landscape disturbance.

Study of geochemical essence of the technogenic landscape modifications might be a basis for ecological regulations of heavy metals content, i.e. a study of the stage character of disturbance. The main issue in these studies is their complex and quantity characteristics investigated under natural conditions.

Such methods were used to determine heavy metal pollution from „Severonickel” factory, dangerous for the landscape of the northern taiga. A critical input of nickel amounts to 0.05 - 0.005 t/km annually, copper – 0.03 - 0.003 t/km², cobalt – 0.001 t/km² annually. The base value of nickel levels in the landscape elements, inherent to the zonal landscape, in the given case of the northern taiga have been following: air – 0.005 - 0.007 mg/m, snow – 0.005 mg/l, water - 0.2 - 0.1 mg/l, soil - 0.003 -0.005%.

**Dynamics of the landscape technogenical modifications (1973-1986)**

In 1973 - 1986, we observed the dynamics of the northforest landscape technogenical modifications. Generally, we have succeeded in discovering that the technogenic modifications of the northforests landscape simplify its morphostructure and form technologically changed complexes. Size of the row modifications is extended from 4 to 7 because of differing landscape stability towards technodenical influence. We have been able to determine intermediate state of relationship between TM-1 and TM-2, TM-2 and TM-3 etc. In this way, in natural complexes of lake-glacial plain subsidences and padings with sedge-bogs ding off biom is the result of more slow, then at elevation plots; the dieing off biom is projected at the surface and soils ding off. However, safety of soil profile allows to distinguish intermediate state of relationship between TM-1 and TM-2.

In 13 years, the urotshitshes of the middle and lower parts of the mountain massifs slopes, morainic hills and kames, and also between-hills reductions in state TM-4 in radius of 1,6 to 2 km from the factory have been exposed to the strongest change. Two-stepped and one-stepped negative dynamics (the transition of complex from weakly violated too very changed) may be observed at the distance of 20 km.
A transition from state TM-4 to state TM-2 took place, there. Wood storey fell out completely (fir, pine, birch), grass-bush storey has been markedly damaged, and soil have been maintained partly.

Slopes of morainic hills suffered one-stepped changes from TM-4 to TM-3 at the distance exceeding 3 km. Natural complexes of the upper parts of morainic hills and kams changed from TM-3 to TM-2 or from TM-2 to TM-1.

It is worth emphasizing that the greater part of complexes (over 50% of an area) maintained former state; it is significant that dynamics is zero. It is as a rule, or is very changed complexes to state technogeom or complexes of lake-glacial plain with optimal correlation of warmth and moisrure for northern taiga. In natural complexes state TM-1, that is deprived soil-vegetation cover, large areas of unconsolidated rocks and solid rocks are exposed, and heavy metals are accumulating at plots of unconsolited rocks, which are extant hoe mosaic; therefore, natural-territorial complexes state is aggravated.

**Geochemical characteristics of technogenic modification dynamics in 1973 - 1986**

In 1970 - 1973, in very changed landscapes (TM-1) heavy metals have been accumulating (Ni, Cu, Co). An increase in their total content in upper laures of soils exceeded baseline values by over 250 times for Cu, 150 - for Ni, and 30 - 50 times for Co. In 1987, this significant increase has been the following: Ni - 400 times, Cu - 400, Co - 80 - 100, Ag, Pb, Cr, Sr - 10 - 20 times over baseline value. In soil, total content of Ni (700 10% ) exceeded Cu (400 10 % weight), and Co (30 10 % weight) content. Therefore, in accumulating heavy metals Ni, Cu, Co predominated. The correlation between heavy metals total content, and their levels in both HCl and aqueous soil samples extracts is the following: Ni - 100:20:0.1-1.1 %, Cu - 100:50-80:0.5-2.5 %, Co - 100:25 - 0.03-0.3 %. It is worth stressing, that in soil fine sand of epicentre pollution both acid and water-soluble Cu, Ni, and Co salts increased in comparison with their total content.

At present, in TM-1 of slope urohistshes mountain massifs at middle and lower layer of relief, being deprived of soil-plant cover, pH of fine sand is between 3.0 and 3.9. Sulphate ion concentration is 11.7 mg.eq (0.56 % eq) in the aqueous fine sand extract. Cu is being detected in HCl soil samples extraxt and vary from 100:10 to 160:10 % w/w, Ni - 40 - 50:10 % w/w, Coo = 3 - 85:10 % w/w. It means that Cu in moving form exceeds that of Ni, and Ni content exceeds that of Co. Content of Cr, Pb and Zn is insignificant (17.5:10 to 3:10 % w/w). Thus, the sharp increase in environmental pH and accumulation of heavy metals is typical for TM-1 in upper layer of soils, first of all Ni, Cu, Co.

In TM-2 northern taiga landscape at the distance upto 5 km North and South from the factory Ni, Cu, and Co are accumulating in soil less intensively (KKf Ni 100-250, KKf Cu 10 - 7.5, KKf Co 10 - 15). Total content of heavy metals in soil is less considrable: Ni - 180:10, Cu - 140:10, Co - 12:10 %).

In TM-3, TM-4 at the distance upto 13 - 18 km south and south-west from
factory in upper layers of peat-podzolic soils the accumulation Ni and Cu is between 20 and 50 KKF, Co 3 to 8 KKF, Zn, Ag, Pb and Cr 2 to 3 KKF. Nickel content in soils exceeds that of Cu, and especially that of Co. Heavy metals content diminished sharply with an increase in depth down soils profile, an order of accumulation intensity is changed: Ni occupies the first place, but Cu and Co are removed, Cr, Zn, Al is accumulated more intensively then Cu and Co.

In TM-3, MT-4 of slopes urotishitshes at the distance of 19 - 20 km from the factory to the south in alluvial ferruginous podzol pH in upper soil layers decreased (pH 4.8). Total heavy metals content in soils exceeded natural baseline value by 2 - 3 times.

Sulphates level in aqueous soil samples extract decreased from 0.94 mg. Eq in layer Ao to 0.136 mg. Eq in layer BC. Copper level in HCl extract of soil samples diminished with depth down at two orders – from (100-160) 10 % in upper layers to 4:10 % in layers B and BC. Nickel and cobalt levels are significantly lower (Ni 45.2:10 % weight in peat layer Ao, Ni - 1.7:10% w/w in soil layers B, BC). For natural complexes, which are being found in states TM-3, TM-4, lower acidity of the upper soil layers soils is typical. However, heavy metals content in soils is significant already, enabling to foresee inevitability of technogenic landscape modification.

**Conclusion**

Thus, observations of an effect of acrotechnogenic effect of „Severonickel” factory and simultaneous follow-up of technogenic landscape modification dynamics landscapes allow to draw conclusions concerning an intensification of the technogenic load to the landscapes.

In 13 years (1973 -1986), a sharp increase in Ni, Cu, Co levels in snow cover and soils, especially in environmental pollution, is seen. The whole geometry of influence area is stretched in meridional direction, which is survived. Considerable changes have taken place in the state of natural complexes watersheds, especially of windward slopes.

The whole area of influence have broadened, heavy metals content in soil has increased by 10 times approximately. The results of geochemical analysis should form the basis of ecoloical standardization of the „Severonickel” factory impact for the north-taiga landscapes and should allow to determine precisely the rates recommended by us before.

**References**
