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Influence of Improvement Cutting in Forest Communities of a Nature Sanctuary on Iron Migration in Soil

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Abstract—**The paper is devoted to the study of interphase (solid phase, soil absorbing complex) migration processes of vertical migration of iron in soils of the nature faunal sanctuary. Besides migration processes, the paper considers the influence of various factors on these processes. The comparative analysis of a theoretical model of influence of various factors, designed on the materials of previous research and works of Russian and foreign scientists and the model thus created showed a certain similarity and difference of these models which can be explained by: a) the influence of economic activity on natural communities; b) the set of environmental conditions of the forest-steppe (South) Trans-Ural region.**

Keywords—migration of iron in soil; factors of migration processes; iron migration models; economic activity in nature sanctuary

I. Introduction

The relevance of the study is caused by importance and role of soil in biosphere and human life. Soil is the primary source of mineral (root) nutrition of plants. Therefore, the chemical composition of soil is one of the main factors limiting the biota viability. The content and forms of chemical composition of iron play an important role here.

Iron is a microelement which is the best acquired by plants in comparison with other minerals. It takes the leading role among all metals absorbed by plants.

The main **contradiction** of the considered problem is that the scholars know the main features of iron migration in soil, while the factors influencing these processes regarding soil of a particular region with a variety of climatic conditions, including the forest-steppe Southern Trans-Ural region, the Belozersk Wildlife Refuge, are still not revealed.

The problem of the study is to understand what factors influence the processes of iron migration in soils of the Belozersk nature faunal sanctuary and how cutting (within the authorized economic activity) influence iron migration processes?

The role of soil in plant nutrition has been studied for over 150 years. It is worth noting the interest of scientists of the last decades to the following:

- study of soil features of a particular region: (J. Wang, Z. Li, C. Cai, W. Yang, R. Ma, T. Wang, 2012) [4], (N.V. Gopp, 2015) [2];

- influence of geochemical features of landscapes in migration processes of minerals (E.M. Korobova, B.N. Ryzhenko, E.V. Cherkasova, E.M. Sedykh, N.V. Korsakova, V.N. Danilova, S.D. Hushvakhtova, V.Yu. Berezkin, 2014) [11], (D.V. Moskovchenko, 2012) [10];

- dynamics of certain minerals in the soil-plant system: (migration of heavy metals by G.E. Shumakov, 2017) [9], (migration of iron by L.S. Malyukov, 2011) [14, 15], identification of correlation in this system (N.A. Pudovkin, R.Sh. Mubarakshin, I.Yu. Kutepova, A.Yu. Kutepov, 2013) [16];

- migration processes of chemical elements in a complex soil system, including:

A) iron migration (P. Sipos, T. Németh, Z. May, 2009) [3], (L.A. Matyushkina, S.I. Levshina, D.N. Yuryev, 2006) [12], (G.V. Motuzova, E.A. Karpova, R.S. Aptikaev, 2009) [1], (A.S. Fried, M.A. Goma Botkhina Saad, T.I. Borisochkina, 2016) [6];

B) interphase migration within one horizon (in leached chernozem by A.Kh. Sheudzhen, T.N. Bondareva, Kh.D. Khurum, I.A. Lebedovsky, M.A. Osipov, S.V. Esipenko, 2017) [7];

C) vertical migration of iron along soil profile (V.N. Shoba, 1979) [8], water migration of iron by A.V. Puzanov, S.V. Baboshkina, T.A. Rozhdestvenskaya, S.N. Balykin, 2015) [5];

D) definition of stability of geosystems according to migration of chemical elements (L.N. Semyonova, Yu.M. Semyonov, 2010) [13].

Purpose of the study: to theorize the migration processes of iron compounds in soil, to conduct experimental study on the dynamics of iron content in soils of the Belozersk Wildlife Refuge and its key factors.

Object of the study: biogeocenoses of the Belozersk Wildlife Refuge of Kurgan region.

Subject of the study: migration processes of iron compounds in soil and their key factors.

Sustainable development always satisfies the requirements of the present, but does not threaten the ability of future generations to satisfy their own needs. The Rio Declaration on Environment and Development, known as the Rio Principles, refers to the basic concept of sustainable development, ways of transition to it and its implementation.

The economic growth and development lead to changes of natural ecosystems. Most often, the development depletes ecosystems and reduces species diversity. The disappearance of certain types of biota may considerably limit the choice of opportunities for future generations. Therefore, sustainable development requires the preservation of the maximum biodiversity.

The degradation of natural resources, environmental pollution and loss of biological diversity reduce the ability of ecological systems to self-recovery.

The main standard and legal documents in the field of environmental protection include the Federal Law on Environmental Protection, which is based on the Constitution of the Russian Federation; the Federal Law on Specially Protected Natural Territories of 14.03.1995; the Forest code of the Russian Federation of December 4, 2006, namely, Article 24. General provisions on the use of forest, Article 103; the legal regime of forests located in specially protected natural territories; the Land Code of the Russian Federation No. 136-FZ of 25.10.2001 (edition of 31.12.2017), namely: Chapter XVII. Lands of specially protected areas and objects (Article 94).

II. Methods and Materials

The research object covers biogeocenoses of the Belozersk Wildlife Refuge [17] with sample areas marked on its territory. Phytocoenoses are studied and soils samples are taken from different horizons within these areas.

Methods: **theoretical** – analysis of various sources of information, modeling, comparison, generalization; **empirical (practical)**: definition of iron content by ammonium rhodanate method, potentiometer method to define pH, method of studying humus by Tyurin; method to define labile phosphorus by Kirsanov, statistical and correlation analysis of results [18, 19].

The general biogeochemical orientation of history and migration of iron on the crust surface includes: generation of mobile compounds, their transport and accumulation in transit and accumulative landscapes.

III. Results

Iron under the influence of various factors may pass from one phase into another, changing its state. In a solid phase of the soil, iron is in the form of oxides and carbonates. In soil solution, iron is in the form of free cations. In SAC (soil absorbing complex), iron forms organo-mineral compounds by connecting to humic acids.

According to *literary data*, the major limiting factors of iron mobility between soil phases are as follows: value of soil pH (in sour soils the mobility and availability of iron increases), oxidation-reduction potential – Eh (availability of iron increases with its increase), calcium salts (with their increase in soil the mobility and availability of iron decreases), iron bacteria (iron bacteria participate in iron binding and precipitation thus forming insoluble compounds).

The major limiting factors of iron mobility between soil horizons on a vertical profile are the following:

1) basement rock (ferriferous minerals in basement rocks increase iron compounds in soil) since iron in a mineral form from horizon C gets to horizon B, and from horizon B to A. Besides, there is a reverse transition: from horizon A to horizon B, and further to horizon C, the iron connecting to humus forms organo-mineral forms and settles;

2) soil structure (the better the soil structure, the less iron is washed from soil, i.e. its dynamics slows down);

3) mechanical composition: in light soils the dynamics of iron increases, and in soils with heavy mechanical composition the dynamics of iron slows down.

The dynamics of insoluble (in a solid phase) iron in soil is revealed in the course of study. One out of all studied areas is defined by the fact that the content of soil iron contained in its samples considerably exceeds the content in other samples. It can be explained by the fact that the new growths in the form of concretions with 12.96% of iron were found on this site at a depth of about 1 m.

According to correlation analysis, this phenomenon may be connected with the fact that after cutting the active use of iron by plants is slowed down, and close groundwater occurrence ensures oxidation of soil iron and its accumulation as hydroxides.

The results of the study show that insoluble iron is mainly found in soil within the horizon C. It may be assumed that the basement rocks serve the main source of iron in soil. Iron gets into soil from basement rocks, and the horizon C (parent rock) contacts with basement rock and can smoothly get into it.

Significant amount of insoluble iron is also contained in the horizon B, but slightly less than in the horizon C. This is explained by the fact that this chemical element may be transferred to higher layers due to thanks to ascending current.

Much less soil insoluble iron is contained in the horizon A than in lower horizons. First of all this may be explained by mechanical composition (fragments of rocks in physical sand), and secondly – by the activity of biological cycle – absorption of dissolved iron by plant root system.

The decrease in the content of insoluble iron in higher layers is characterized by vertical ascending dynamics at all areas of the reserve.

The greatest amount of soil insoluble iron in the horizon A is noted in the area of mixed forest westwards from the Zybuchevo Lake. The greatest amount of soil iron in lower horizons is observed in the same area. It can be assumed that in the given area of the Belozersk Wildlife Refuge the basement rocks are placed at a small depth and consist of ferriferous rocks.

Smaller amount of soil insoluble iron is observed in other areas and, generally in lower horizons.

Similar dynamics is revealed for the content of dissolved iron (in soil solution) in soil of the horizons.

The largest content of dissolved iron is observed in areas of 2017 summer cutting near the Bobrovoye Swamp and in the area of mixed forest westwards from the Zybuchevo Lake. In the first area there is more dissolved iron in the horizon C, and in the undisturbed area – in the horizon B.

The territorial horizontal dynamics in all areas of the Belozersk Wildlife Refuge and the dynamics of iron transition from a solid phase into liquid, i.e. into soil solution, is revealed within each horizon.

Besides, the dynamics of territorial migration of iron compounds is revealed within a certain territory, for example, in coastal communities of the Bobrovoye Swamp and the Zybuchevo Lake, as well as in territories exposed to anthropogenic influence including territories of improvement cutting.

In the coastal zone the areas of the Bobrovoye Swamp differ in iron content in soil (in general), there is much more iron in the soil of remote areas. According to the degree of mobility, the dissolved form of iron prevails in soil of this area.

Perhaps, mobile forms of iron are washed from soil of the coastal section due to close location to a reservoir and on a slope (in downslope landscape).

In one area of the coastal zone of the Zybuchevo Lake the iron content is the following: very low content of insoluble and dissolved iron. This area is located in close proximity to a reservoir and on a downslope landscape, hence mobile, dissolved forms of iron are washed thus possibly leading to iron yield from soil when melt and rain water ran off into the lake.

In the remote area from the lake, the content of all forms of iron is much higher. The area is located in the mixed forest, therefore, the run off speed is much lower due to smaller angle of inclination and vegetation connecting iron compounds.

There is insignificant amount of iron in cutting territories, especially in territories exposed to cutting, which vegetation was either is completely destroyed, or is at its initial stage of restoration. Therefore, the impact of biological absorption is excluded here. The soil cover is destroyed, the soil is not structured and easily passes water through. Besides, these areas are located on hillslopes. These three factors lead to iron washing.

One cutting area is located in a small lowland, which ensures the accumulation of iron compounds in this territory. Close groundwater occurrence ensures oxidation of iron and its accumulation as hydroxides. All this contributes to the formation of accumulations in the form of concretions.

IV. Conclusion

1. The obtained results of the study and the correlation analysis made it possible to design models of external influence on the transition of iron from one phase into another within each horizon separately and the model of external influence on the mobility of iron along soil horizons.

2. The internal content of the model includes the transition of iron from a solid phase into a phase of soil solution.

3. Among factors affecting the mobility of iron between soil phases in the horizon A, the pH relevant, the pH exchange and quantity of humus serve as limiting factors. The amount of phosphorus and quantity of hydrocarbonates serve as background factors.

The correlation of the amount of insoluble iron in a solid phase of soil and dissolved iron in soil solution depends on the acidity of soil solution. The lower the pH in the horizon A, the more iron is contained in soil solution.

At low content of humus in revealed samples it is proved that it is generally placed in organo-mineral complex.

Among factors affecting the mobility of iron between soil phases in the horizon B is the pH relevant. The background factors are as follows: pH exchange, amount of humus, content of phosphorus and hydrocarbonates. Among factors affecting the mobility of iron between soil phases in the horizon C are the pH relevant and the pH exchange. The background factors are as follows: amount of humus, amount of phosphorus and hydrocarbonates.

Among factors affecting the mobility of iron within horizons the phase dynamics, mechanical composition and soil structure are the most limiting factors. The background factors are as follows: humidity of soil, vegetation, oxygen content and soil microflora (iron bacteria).

There is a partial compliance between theoretical and obtained models.

The results of the study confirm the assumption that the improvement cutting dies not only change the nature of vegetation within exposed territories, but also affects the migration of iron in soil.

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