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THE IMPACT BIRCH TREES COMMUNITIES ON CHEMICAL PROPERTIES OF SOILS IN CENTRAL POLAND

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Abstract

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In the last decade the rate of abandoned land in Poland increased from 0.16 mln ha (1.1%) in 1990 till 2.30 mln ha (17.6%) – in 2002. The part of abandoned land is usually covered by birch tree community. The entrance of birches changes properties of soil, especially on pure sandy area. The samples of soil horizons, litter in different stages of decomposition and leaves from birch trees, were taken into laboratory analysis. Birch role was analysed also in comparison to arable land, abandoned land without trees and different ages birch trees communities. The entrance birch trees on abandoned land make soil more acid (average one pH units) in upper soil horizons. They were enriched in nitrogen and elements such as aluminium, iron, cadmium, lead, cobalt, zinc, which were moved from soil or come from atmospheric load and were accumulated in litter or humus horizon. In soil profile the maximum of nitrogen were moved from humus horizon to sod horizon. Magnesium and phosphorus were accumulated in birch leaves and in litter horizon. Compared to arable land, some elements (for example calcium) had lower concentration under birch trees. The contrast in element concentration in soil between upper soil horizons (litter and humus horizons) and underlying horizons is lower and concentration course of concentration line was more regular. After several years without fertilization the relationship between elements were changed. In early stages (until 10 years) in litter horizons potassium prevails calcium, later – calcium prevails potassium. Birch trees made soil environment more natural compared to arable land.

Key words: abandoned land, birch, plant and soil relationship, oligotrophic sites, bioindicators

Introduction

In the last decade of 20th century was possible to observe increasing the rate of abandoned land in the structure of land use in Poland. It had increased from 0.16 mln ha (1.1%) in 1990, till 1.67 mln ha (9.2%) – in 2000 and 2.30 mln ha (17.6%) – in 2002. Nowadays one of five hectares is classified as abandoned (uncultivated) land.

The part of abandoned land was usually covered by birch tree community. That process was natural in same of its aspects conditioned by reproductive properties of birch (anemochory – light and winged seed were transported on long distances by wind). The birch trees have some positive impact on soil properties. They roots have sufficient power to perforate soil compaction horizons. That is one of reasons why birch is implemented as an addition in pine forest plantation. It looks to be interesting to investigate also impact of birch tree communities on chemical properties of soil.

Materials and methods

This study was conducted ca 40 km east of Warsaw were focused on birch impact on chemical properties of soil. It is a sandy area, represented by podzolic soils, used as arable land. Among farm land are small patches of pine plantation and birch tree communities. Environmental conditions on research plots are relatively equal, because of small distances of researches plots (12 plots at two sites). Field research took place in 2001 and 2002.

Sampling. To investigate the problem standard soil-geochemical methods were used. The samples of soil horizons, litter in different stages of decomposition and leaves were taken for laboratory analysis. In order to answer the question of birch role in landscape the researches come outside of birch trees communities, so research plots were established also in arable land, abandoned land without trees and in different ages birch trees communities.

Results and discussion

Vertical profiles of elements concentration in birch tree communities. The entrance birch trees on abandoned land changes chemical regime of landscape. In comparison to arable land output of elements is minimized and they are accumulated in plant material, litter and soils horizons. Such a process is able to observe in concentrations of elements in different compartments of physical environment. In order to describe a role of birch tree samples of some other species were also taken into laboratory analyses. It can be distinguished some models of vertical distribution of elements:

I. Model of proportional distribution of elements (Fig. 1); they occur higher concentration at the some species (birch and aspen) and the litter soil horizon. It operates for trace elements (Zn, Co etc.), which are transported to researches plots as an atmospheric load.
II. Model of higher concentration of elements in soil horizons. It operates for such elements like Al and Fe, which occur in parent soil material and soil is a source for uptaking elements by plants.
III. Model of higher concentration of elements in organic material (trees and litter horizon) and lower concentration in ground cover (grasses). It concerns Zn and Mn, elements playing important role in structure and function of tree leaves).
IV. Model of highest concentration in upper soil horizons (litter and humus horizons) consist humus substances responsible for sorption properties. It effects for Pb and Cr, ele-

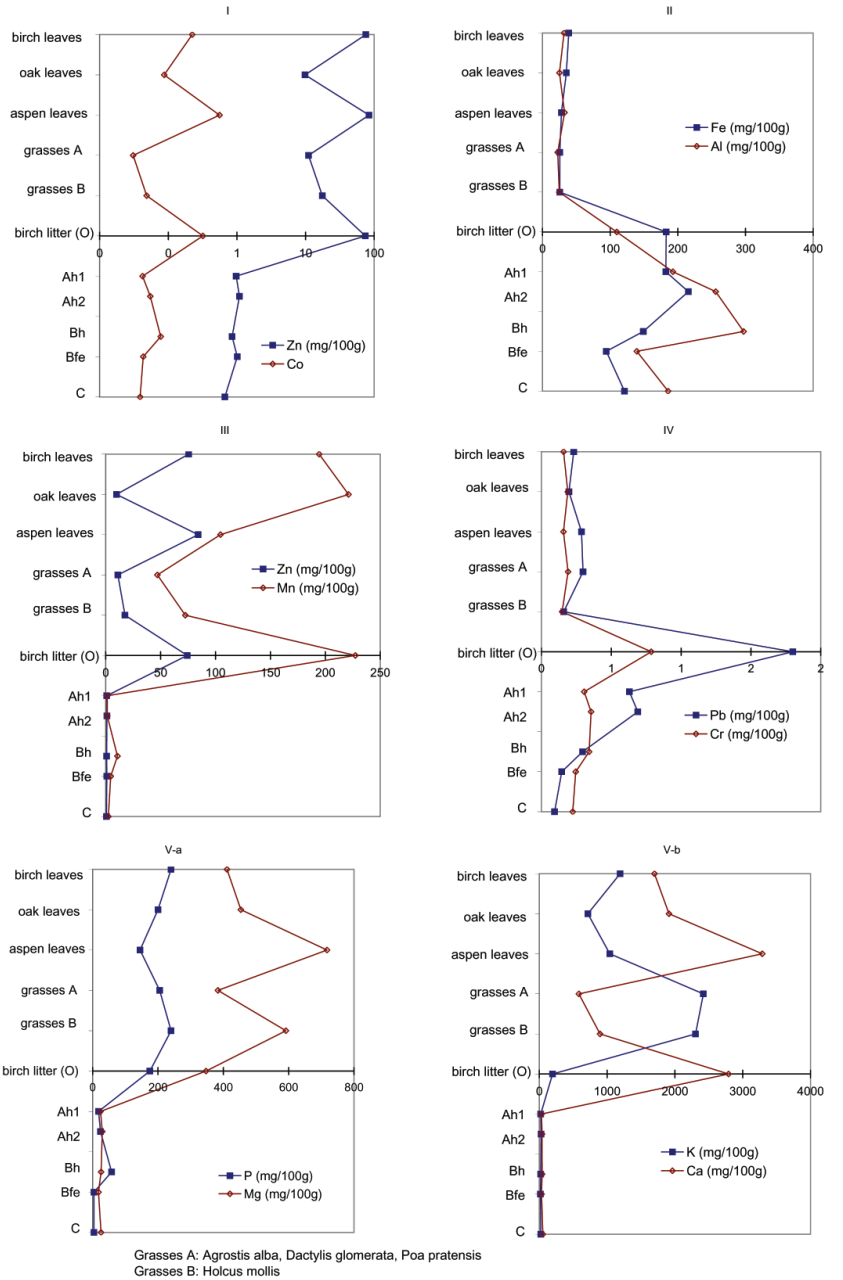

Fig. 1. Model of vertical distribution of elements in the compartments of birch tree communities.

ments with highest sorption possibilities, which are adsorbed before others elements. In opposite to Zn and Mn they are not desirable by plants.

V. Model of biophilous elements. They are concentrated in plants organs and due to leaves fall are going down to litter and soils horizons (variant V-a for P and Mg) or they are specifically absorbed opposite to each other (variant V-b for K and Ca).

That models are more complicated in comparisons to arable land models. The entrance birch trees on abandoned land made soil more acid (average one pH units) in upper soil horizons (Fig. 2). It can be said that, birch trees made soil environment more natural compared to arable land. More differences were found in upper soil horizons. They were enriched in nitrogen and elements such as aluminium, iron, cadmium, lead, cobalt, zinc, which were uptaked from soil or come from atmospheric load and were accumulated in litter or humus horizon.

In soil profile the maximum of nitrogen were moved from humus horizon to sod horizon. Year by year nitrogen was accumulated under birch trees communities, but was removed in arable land condition. Higher content of nitrogen in cultivated land is connected with manure and mineral fertilization. This process not occurs in birch tree sites, so we can see long-term decreasing of nitrogen content in poor soil conditions.

On the way of looking for optimal indicator of impact birch communities on soil, we have to assume that the elements, which are in huge con-

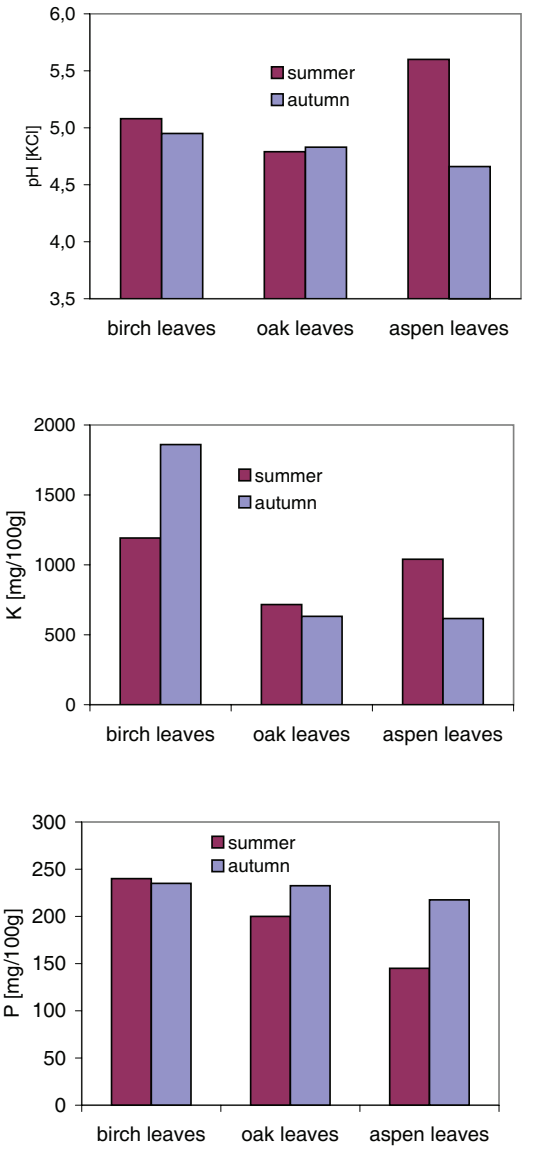

Fig. 2. Comparison of elements content in soil under birch tree, abandoned land and arable land.

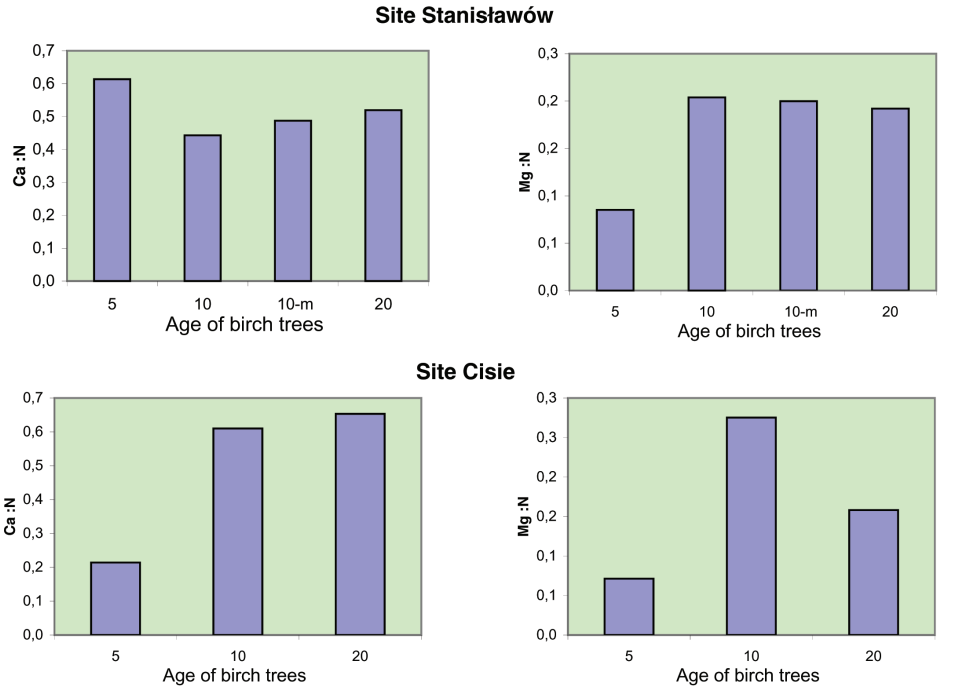

Fig. 3. Seasonal changes of some elements in tree species in birch tree communities.

centration in soil cannot play such a role. We have to put them away and choose indicators with such a features as: mobility, high level of bioavailability and low concentration in soil.

Comparing to arable land, some elements (for example calcium) had lower concentration under birch trees. Under birch trees the contrast in element concentration in soil between upper soil horizons (litter and humus horizons) and underlying horizons is lower and concentration course of concentration line was more regular (Fig. 4). Magnesium and phosphorus were accumulated in birch leaves and in litter horizon. Quite differently looks vertical profile of trace elements content (lead, cooper). In arable and abandoned land they are accumulated in humus horizon, under birch tree their peak is shifted also into mineral soil horizons. It suggests, that in cultivated land conditions, trace elements were removed with annual plant crop, so they had been not able to go deeper and we were not able to notice long-term trace elements accumulation process in cultivated soil.

After several years without fertilization the relationship between elements were changed. In early stages (until 10 years) in litter horizons potassium prevails calcium, later – calcium prevails potassium. In research area condition, potassium looks like an elements, which is in short supply and which can determine the limitation for tree growth.

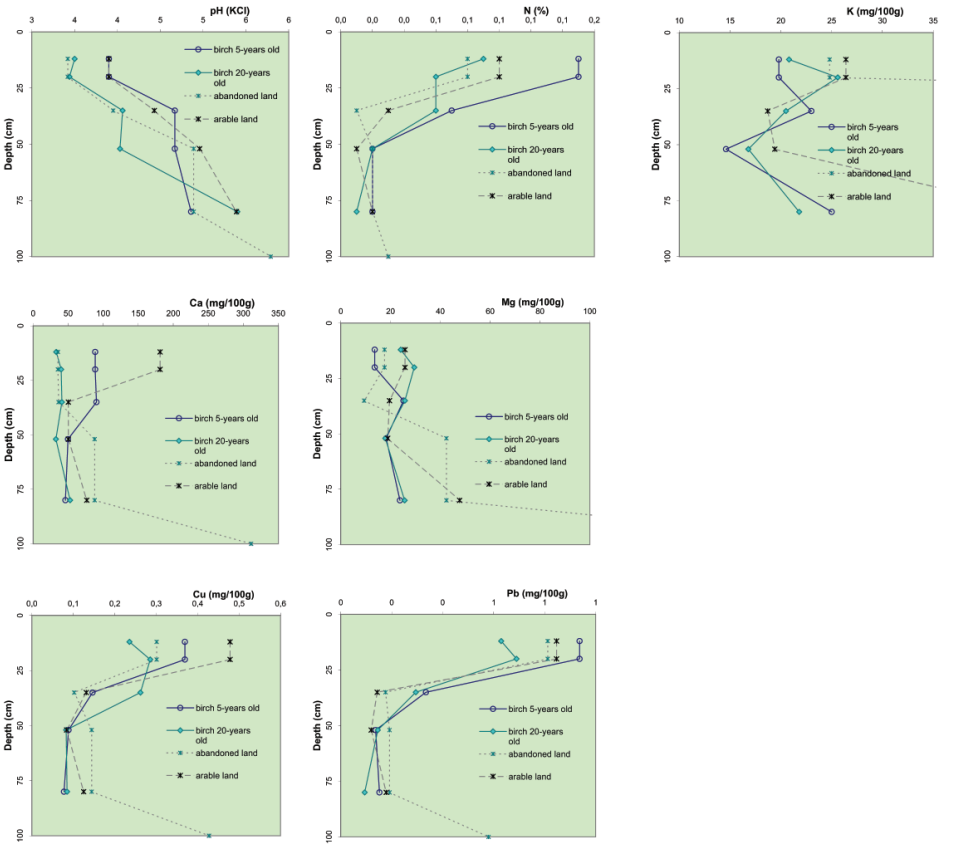

Fig. 4. The Ca:N and Mg:N ratio in birch leaves according to different ages of birch tree communities (10 m – birch tree communities with the meadow species in ground cover).

Same elements differ between the age of birch tree. Phosphorus and nitrogen content was higher in young stages of natural succession and decreased in 10–20 year old class. The another researches are shifted the limit of young stages of birch physiology into 20 year old birch (Hrdlička, Kula, 2001). The phosphorus decreasing content is connected also with nitrogen availability in soil (Evans et al., 2001). In litter soil horizons of younger stages of birch communities prevails potassium, in older stages – prevails calcium and concentration of phosphorous, magnesium is decreasing.

At the poor soil, content of nitrogen is irrespective of the age and site (Heilmeier et al., 2000). The significant growth of leaves mass is in young stages of age, when concentration

of nitrogen is low. In older stages growth of birch leaves mass is small, but concentration of nitrogen is higher (Evans et al., 2001). The total mass of nitrogen is relatively equal, it is uptaking by birch roots and accumulated in organic matter.

The concentration of elements can be different in leaves and another birch tree organs during vegetation period (Oleksyn et al., 2000; Tarabuła, 2000; Evans et al., 2001). In autumn same elements (N, P, K, Mg) are migrated from birch leaves to branches. That processes were also observed on researched area (Fig. 2) and the differences between summer and autumn elements concentration is approximately 30–40%. We can agree that birch (compared to pine and spruce) is best adapted to poor environmental conditions (Smolander, Kitunen, 2001; Tytti, Seppo, 2002). Birch does not improves chemical properties of soil, but it moves the elements from deeper soil horizons into environmental cycle and makes its more complete.

Conclusions

The 10-years old birch tree are nearly full structured community. It has appearance in the matter budget (trees are returned significance elements into soil; in earlier stages birch trees grows rapidly and the soil looses a lot of elements).

The abandonment accelerates accumulation of some biophilous elements such as nitrogen and potassium.

Generally, the birch trees consume the elements, which were outside of root zone at the arable land utilization. The birch entrance allows appearing the spices suitable to environmental condition, alter soil nutrient pool, their cycling and transforming the geosystem into quasi-equilibrium state.

Especially, decreasing of nitrogen content and increasing of trace elements in upper soil horizons are the indicators of naturalization process.

Abandonment and reforestation can be major factor of landscape and soil changes in Central Europe in first two decades after accessing to European Union.

Translated by the author

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