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DIFFERENTIATION OF CHEMICAL PROPERTIES OF FOREST SOILS IN THE RANGE OF BEECH TREES (*FAGUS* SP.) UNDER THE INFLUENCE OF ATMOSPHERIC POLLUTION IN THE DOBRZANY FOREST INSPECTORATE OF THE WEST POMERANIA DISTRICT

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A b s t r a c t. The author investigated a 0-3 cm layer of two forest brown soils: brown acid and brown leached. These forest soils were under handsome beech trees (*Fagus* sp.) between 100 and 120 years old. The author compared the chemical properties of the soils. The soil existing near the tree trunk (1 m^2 of surface, strongly washed by rain water polluted by chemical substances) and the soil existing under the tree umbrella (40 m^2 of surface in the area of the tree-tops, washed poorly by rain water). This comparison showed changes in these properties, dependent upon the degree of atmospheric contamination.

It was found that, at the same level of atmospheric contamination, higher changes of properties were found in brown leached soil than in brown acid soil. Less acidified soils (with alkaline or neutral pH reaction) are more suitable in these researches. The investigations of the forest soil layer 0-3 cm (12 soil profiles) showed that changes in their chemical properties in relation to tree trunk-tree umbrella can be the basis of assessment of the degree of atmospheric contamination.

K e y w o r d s: forest soils, beech trees (*Fagus* sp.), atmospheric pollution, washing of soil.

INTRODUCTION

Atmospheric pollutions, as other anthropogenic factors, cause a decrease of agricultural production in cultivated soils. This problem has been investigated over many decades by many scientists [1-3,5,8,11]. Traditional soil researches do not permit this problem to be investigated clearly. Forest habitat, mainly in the range of beeches (*Fagus* sp.), give researchers a better possibility of finding atmospheric deposit influence on soils. Soils receive atmospheric pollution mainly in the form of wet deposits as a result of rain water. The rain water is taken by the upper surfaces of the trees after which it trickles down to the tree trunk (14% of rain water). This amount of water permeates 1 m^2 of soil surface. 69% of rain water permeates 40 m^2 of soil surface [4]. The degree of changes in soil properties caused by chemical components included in rain water, should be proportional to the quantity of filtration water. The increase in the quantity of filtration water near the tree trunk should cause higher soil changes than that under the tree umbrella. The higher differentiation of the properties of the soils chosen in the system tree-trunk-tree umbrella should be observed in an area with higher atmospheric deposits.

The author investigated the soil grain composition of loamy sands (boulder sands, under sands where light loam exists). The soils investigated were classified according to type as brown, in two subtypes: brown acid and brown leached. These soils were under old beech trees (100-120 years old) in the Dobrzany Forest Inspectorate.

The aim of this research was to show the most sensitive chemical properties of the soils to the influences of filtration water polluted by chemical components (atmospheric deposits). The research was aimed at showing the differentiation of chemical properties in a 0-3 cm layer of soils: surrounding the tree trunk (higher intensity of washing) and under the tree crown umbrella (lower intensity of washing). The results strove to show the influence of the atmosphere on brown soils: acid and leached.

METHODS

Cumulative soil samples were taken superficially from a 0-3 cm layer, near the tree trunk and under the tree umbrella from ten trees (beeches) chosen randomly. Two soil samples were taken from one tree; from the entire surface, 20 samples were taken (10x2). The researched surface was represented by two soil profiles. Type classification was made on the basis of the morphology built of the soil profile, and the chemical and physical properties of the genetic horizons.

The area investigated in the Dobrzany Forest Inspectorate was represented by two soils: brown acid soil taken from a small mound (with an 8%-9% gradient) and brown leached soil extracted from a flat area. The area investigated was a small undulating area of ground moraine.

Soil samples were taken from a 0-3 cm layer on three occasions: 22.09.1992, 20.04.1993, and 28.10.1993.

In these soil samples, the following properties were determined:
- grain size composition according to Casagrande in modification of Prószyński;
- pH potentiometrically;

- hydrolytic acidity and sum of cations with alkaline character, acc. Kappen;
- exchangeable forms of aluminum and exchangeable acidity, acc. Sokołow;
- content of exchangeable cations (Ca^{2+}, Mg^{2+}, K^{+}, and Na^{+}) were determined with atomic absorption spectrophotometer (AAS) in soil solid extracted by 1n CH_3COONH_4 (pH=7.0);
- content of total nitrogen, acc. Kjeldahl;
- content of organic carbon, acc. Tiurin.

RESULTS

The brown acid soil from the Dobrzany Forest Inspectorate, in a 0-3 cm layer showed: average humus content near the tree-trunk 10.01%, average content of grain fraction <0.002 mm - 5.7%; in the tree umbrella area, the average humus content - 7.93%, average content of grain fraction <0.002 mm - 4.6%. The beeches growing in this area were less handsome; pines and spruces were growing near the area under investigation.

The brown leached soil, in this 0-3 cm layer, showed: near the tree trunk an average humus content - 5.99%, an average grain fraction content of <0.002 mm - 6.0%; in the area of the tree umbrella: average humus content - 4.66%, average content of grain fraction <0.002 mm - 5.83%. The beeches grown in this soil were very handsome, in the undergrowth, grasses and young beeches were in evidence. The influence of rain water on the soil in which handsome beeches were grown should be clear.

Both adjacent soils had very different properties of humus horizon (0-10 cm) (Table 1). The brown acid soil had a higher acidity than the brown leached soil.

The investigations showed that changes in properties in the 0-3 cm layer caused by atmospheric deposit and different quantities of filtration water were dependent upon the chemical properties of the humus horizon.

The chemical properties of soils in the 0-3 cm layer are shown as average values in Tables 2 and 3.

In brown leached soil (with lower acidity), lower values were ascertained of the following soil properties of material taken from an area in the vicinity of the tree trunk in relation to soil material taken from under the tree umbrella: the sum of cations with alkaline character (S) - 7.9 times lower nearer the tree trunk, degree of sorption complex saturation (V) - 10.56 times lower near trunk tree, content of Ca^{2+} cations - 5.1 times lower and content of Mg^{2+} cations - 1.19 times lower. Simultaneously, values of the following properties were higher near the tree trunk in relation to

Table 1. Chemical properties of the humus horizon of brown acid soil and brown leached soil from the Dobrzany Forest Inspectorate

Soil	pH	S $cmol^{(+)}/kg$	H^+ $cmol^{(+)}/kg$	V (%)	Al^{3+} $cmol^{(+)}/kg$
Brown acid	3.5	0.9	23.6	3.7	2.2
Brown leached	4.8	8.25	4.58	64.3	0.2

Table 2. Chemical properties (average values) in layer 0-3 cm of brown leached soil from the Dobrzany Forest Inspectorate

Chemical properties	Soil near tree trunk	Soil from tree umbrela	Proportion of higher to lower values
pH H_2O	3.7-4.6	4.3-4.9	-
pH KCl	2.6-3.6	3.0-4.6	-
S, $cmol^{(+)}/kg$	0.51	4.05	7.94
Hh, $cmol^{(+)}/kg$	14.02	7.73	1.81
T, $cmol^{(+)}/kg$	14.46	11.77	1.22
V, %	3.74	39.50	10.56
H^+, $cmol^{(+)}/kg$	0.75	0.21	3.54
Al^{3+}, $cmol^{(+)}/kg$	1.25	0.70	1.78
H_w, $cmol^{(+)}/kg$	2.00	0.91	2.20
Ca^{2+}, $cmol^{(+)}/kg$	0.75	3.80	5.06
Mg^{2+}, $cmol^{(+)}/kg$	0.33	0.39	1.18
K^+, $cmol^{(+)}/kg$	0.28	0.20	1.40
Na^+, $cmol^{(+)}/kg$	0.08	0.04	2.00

Table 3. Chemical properties (average values) in layer 0-3 cm of brown acid soil from the Dobrzany Forest Inspectorate

Chemical properties	Soil near tree trunk	Soil from of tree umbrela	Proportion of higher to lower values
pH, H_2O	3.2-4.4	3.4-4.5	-
pH, KCl	2.6-3.1	2.7-3.3	-
S, $cmol^{(+)}/kg$	1.43	0.58	2.46
Hh, $cmol^{(+)}/kg$	21.47	19.25	1.11
T, $cmol^{(+)}/kg$	22.90	19.83	1.15
V, %	6.24	2.92	2.13
H^+, $cmol^{(+)}/kg$	0.49	0.54	1.10
Al^{3+}, $cmol^{(+)}/kg$	1.50	2.87	1.91
H_w, $cmol^{(+)}/kg$	1.99	3.41	1.71
Ca^{2+}, $cmol^{(+)}/kg$	0.59	0.75	1.27
Mg^{2+}, $cmol^{(+)}/kg$	0.11	0.14	1.27
K^+ $cmol^{(+)}/kg$	0.35	0.32	1.09
Na^+, $cmol^{(+)}/kg$	0.13	0.07	1.85

the area of the tree umbrella: content of Al^{3+} ions - 1.78 times higher near the tree trunk, content of H^+ ions - 3.57 times higher near the tree trunk.

In brown acid soil (with higher acidity) changes of properties were the opposite. The following values were higher near the tree trunk in relation to the tree umbrella: S - 2.46 times and V - 2.13 times. Simultaneously, values of the following properties were lower near the trunk in relation to the tree umbrella: content of H^+ - 1.1 times lower near the trunk; content of Ca^{2+} - 1.27 times lower; content of Al^{3+} - 1.20 times lower. Rain water caused an increase in alkaline cations content (Mg^{2+}, K^+, Na^+).

The received data showed that clear process of washing appeared in layer 0-3 cm of brown leached soil. Sorption complex of this soil (earlier rich in alkaline cations) lost these ions under the influence of H^+ ions present in the rain water. This process of washing caused an increase of potential acidity (increase of H^+ and Al^{3+} participation in sorption complex) and simultaneously it caused a decrease in the degree of sorption complex saturation (V).

The sum of cations of an alkaline character (S) increased in the investigated layer of brown acid soil (earlier poor in these cations). The alkaline cations may have been delivered from a larger, organic horizon as a result of buffer reactions. The atmospheric deposit may also have been a source of them.

This example of both brown soils from the Dobrzany Forest Inspectorate (with different chemical properties of humus horizon) shows that reactions upon the atmospheric deposit depends on the chemical state of the soil. Soils with different degrees of acidity could be shown to demonstrate opposite reactions (changes of properties) in place of contact two horizons: organic and mineral-organic. The reactions in bigger, organic horizon and buffer reactions of superficial layer of humus horizon (0-3 cm) can play a big part in these changes. This layer often has higher contents of humus and colloidal fractions (<0.002 mm) than whole humus horizon. These two parameters increase the power of buffering.

Forest soils from other Forest Inspectorates showed a lower differentiation of chemical properties in a 0-3 cm layer than soils from Dobrzany [9]. This is why it can be said that Dobrzany received a higher amount of atmospheric pollution. This was confirmed by the results of forest monitoring. Dobrzany was not used in isolation for this research. Also used was the monitored data of the adjacent locality - Bierzwnik, showing the approximate quantities of pollutants: SO_2 - 3.74 $t/km^2/year$, NO_x - 0.14 $t/km^2/year$, dust - 67.20 $t/km^2/year$. The data of forest monitoring is still imprecise on account of the research methods employed [6]. Many authors write about increased acidity due to chemical agents from the atmosphere. They confirm that nitric and sulphuric acids, which deliver H^+ ions in contact with the soil, cause this acidity. The influence of the atmosphere is more clearly noticed in less acidified soils (with higher values of sum of alkaline cations - S and pH reaction), for tree-populations in brown leached soil. In these conditions, cation Ca^{2+} is washed into the soil profile and the quantity of absorbed H^+ ion can be an indicator of change in soil acidity. The decrease of participation of Ca^{2+} cations (and other alkaline cations) in sorption complex can appear as changes of acidity.

In more acidified soils (little alkaline cations in sorption complex in layer 0-3 cm); the washing process is more difficult (most often cation Ca^{2+} is washed). This soil has possibilities for the sorption of other alkaline cations as Mg^{2+}, K^+, and Na^+. They can be deposited by the atmosphere (for instance, from the dust of this deposit) or can be washed away from the surface of tree leaves by rain water [7]. The influence of the atmosphere on the increase in soil acidity is a lengthy process. Data from the literature [10] shows that values of pH reaction decrease only about one unit in forest soils even after 50 years or more. These changes are evidenced mainly in the superficial part of the forest soil, for instance in the humus horizon. Both soils from Dobrzany and also a researched alkaline soil (pararendzina) from the Szczecin City Park distinguish themselves from groups of other researched soils [9]. The other, more acidified soils create a separate group of soils with a proportion of chemical property changes near the trunk and under the tree umbrella in the range 1.6 - 2.46. This confirms that less acidified forest soils (neutral or alkaline) are more suitable for research on the influence of the atmosphere on soils.

CONCLUSIONS

1. The soil reaction in layer 0-3 cm on the influence of the atmosphere deposit is dependent upon: specific properties of soils, i.e. grain composition; chemical properties of humus horizon shaped in the process of soil-formation; quantity and chemical composition of atmospheric deposits.

2. Less acidified or neutral soils influenced by atmospheric deposits in the tree trunk area show higher and clearer changes of chemical properties in relation to more acidified soils.

3. Higher changes influenced by atmospheric deposits show the following chemical properties of soil layer 0-3 cm: sum of alkaline cations (S); degree of sorption complex saturation (V); content of exchangeable ions H^+, Al^{3+}, Ca^{2+}, Na^+. These chemical properties were accepted as indices of change in this research.

4. The results obtained complete the knowledge of the influence of atmospheric pollution on soils of the forest ecosystem and of the adjacent agroecosystem. The

results confirm the necessity of considering the influences of the atmosphere on arable land.

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