Forest soil acidification in the Czech Republic

E. Klimo[1], J. Materna[2], V. Lochman[2], J. Kulhavý[1]

[1]*Faculty of Forestry and Wood Technology, Mendel University of Agriculture and Forestry Brno, Brno, Czech Republic*
[2]*Forestry and Game Management Research Institute, Jíloviště-Strnady, Czech Republic*

ABSTRACT: Damage to forest stands and their decline in the Czech Republic evoked a necessity to elucidate the function of soil in these processes. Main factors affecting acidification of forest soils are assessed in the paper. On the one hand, it refers to natural factors such as properties of soil-forming substrates and species composition of forest stands, on the other hand, to the effects of anthropogenic character such as influences of man-made spruce monocultures and effects of acid depositions. Special attention is paid to the development of forest soils in the Krušné hory Mts., where the effects of acid depositions are highest.

Keywords: forest soil acidification; natural and anthropogenic effects

Plant production in natural and semi-natural plant communities is controlled by a number of relationships between biological processes on the one hand and physical and chemical factors of the atmosphere and soils on the other hand. The importance of relationships within an ecosystem consists in the fact that any change in the system component no matter how small can induce changes in its other part. Therefore the soil plays an important role within forest ecosystems because it affects resistance and resilience to a considerable extent and thus the stability of the whole system. Attention is paid both to the development of soil (soil processes and soil properties) and to relationships between soil and plant (soil fertility). The rate and intensity of soil processes have already been the subject of interest of soil scientists for a long time because the rate and intensity not only explain potential anthropic impacts on these processes in the past but also they are a condition for elaborating the prediction of potential consequences of human activities in the development of soil properties closely related to forest soil fertility. The soil itself can be regarded as a relatively stable component of forest ecosystems considering the long-term character of its genesis. Of course, possible destructions of this subsystem can result in a serious reduction of the production level of forest stands or even in the collapse of a forest ecosystem as a whole. Therefore potential consequences for changes and development of soil processes and soil properties are important from the aspect of present evaluation as well as from the aspect of their future development.

MATERIAL AND METHODS

With respect to a fact that the paper was prepared as a contribution for a scientific conference, results of long-term studies of authors from particular university departments mentioned above were the source of data and their evaluation. Methodical procedures were chosen as a discussion on the harmonization of certain fields of the given subjects. Methods of obtaining data in particular workplaces were not the subject of discussion because it referred to methods approved by opponents during the final evaluation of particular subjects.

Natural factors affecting soil acidity in the CR

Parent substrates (soil-forming substrates) appear to be an important primary factor influencing acidity of forest soils in the territory of the CR. Generally, we can state that substrates of acid character predominate. It applies particularly to crystalline rocks such as granite, gneiss, mica schist, Cretaceous sandstones and also sandstones of Carpathian flysch. On these rocks under the interaction of climate and plant cover, soils developed being of acid reaction such as Podzols and acid Cambisols. Soils of slightly acid reaction such as Luvisols were formed on loess sediments and soils saturated with basic elements on igneous basic rocks of the České Středohoří Mts. Of special character are the soils that developed on alluvia of the Labe, Odra, Morava and Dyje rivers which can be primarily of neutral to slightly alkaline reaction. Soils developed on limestone karst rocks are of neutral acidity. MAŘAN (1944, 1948) also attributed the importance of natural soil-forming factors for the condition of soil acidity according to particular soil types but the character of surface humus was considered to be the principal factor. The fact was then generalized by MAŘAN (1948) as follows: (1) humus of closed conifer stands is much more acid than that of closed broadleaved stands of the same region, (2) forest floor layers are more acid than layers of mineral soil.

Similarly ZLATNÍK et al. (1938) studying natural forests of Trans-Carpathian Ukraine described sites where soil acidity of upper horizons reached 4.5–4.8 pH and in some cases even 3.8, 3.6 and 3.4 pH.

Therefore, in studying anthropogenic impacts it is necessary to take into consideration this natural condition affecting also the sensitivity of soil to acidification by spruce monocultures and particularly by acid depositions.

In assessing the sensitivity of soils to acidification by air pollutants, it is possible to take into account the opinion of WIKLANDER (1978) that very acid soils are far less sensitive to further acidification. They are relatively stable, their pH being usually lower than pH of precipitation. Particularly podzol soils and acid brown forest soils rank among these soils. In coniferous forests, WIKLANDER (1978) considers decomposition processes of organic matter to be the main source of acidification.

A special case can occur if E horizon is completely impoverished of soil colloidal fractions by podzolization processes and only an inert fraction of siliceous sand remains in it as shown by the profile of marked podzol developed on Cretaceous sandstones in the area of Doksy (NW Bohemia):

Horizon	pH in H_2O	pH in KCl
A	4.1	3.2
E	6.1	5.4
Bh	4.1	3.7
Bs	5.1	4.8
Cd	5.6	4.8

The marked change in the species composition of forests in the territory of the Czech Republic is an important factor of forest soil acidification which can partly be attributed to anthropogenic effects. The change began already in the Middle Ages by the preferential felling of beech for the manufacture of charcoal and potash. Marked changes occurred particularly in recent two centuries as shown in Table 1.

The most dramatic change occurred particularly in favour of spruce while beech suffered the largest decrease. Thus monocultures of spruce appeared that were distributed in lower vegetation zones. The change in the composition of forest stands was reflected particularly in changes in the amount and properties of surface humus. For example, the accumulation of organic matter on the soil surface in beech stand, mixed beech/spruce stand and in spruce monoculture on Luvisol developed from 16.9 to 77.8 t/ha in the course of the first generation of spruce. The change also markedly affected pH values of soil surface A horizons (Table 2).

The process of soil surface acidification is also related to differences in the concentration of basic cations (Ca^{++} and Mg^{++}). The differences in surface humus layers and in A horizon were as shown in Table 3.

The effects of spruce stands are also demonstrated by pH values of soils in the National Reserve Boubín – the Šumava Mts. in stands dominated either by beech or by spruce. In the stand dominated by spruce, a thick acid H layer was created, which also resulted in a significant decrease of pH in KCl (exchangeable acidity) (Table 4).

During the inspection measurements of changes in pH values of soils in the Beskydy Mts. after about

Table 1. Change in the species composition of forests in the territory of the Czech Republic

Species composition (%)	Spruce	Fir	Pine	Larch	Oak	Beech
Natural	11.0	18.0	5.4	0.0	17.2	37.9
Present	54.2	0.9	17.6	3.7	6.3	5.9

Table 2. pH of soil horizons under forest stands of different species composition

Species composition	Horizon			
	A		E	
	H_2O	KCl	H_2O	KCl
Beech	4.65	3.87	4.33	3.55
Beech, spruce	3.89	3.28	4.33	3.44
Spruce	3.85	3.04	4.26	3.71

Table 3. Concentration of basic cations (Ca^{++} and Mg^{++}) under forest stands of different composition

Plot	Layer	Ca	Mg
		(g/kg)	
Beech	L	12.3	1.45
	F + H	9.0	1.24
	A	1.73	1.95
Beech, spruce	L	12.4	1.44
	F + H	10.3	0.97
	H	4.6	1.36
	A	1.15	1.77
Spruce	F + H	8.62	0.57
	H	3.35	0.60
	A	0.64	0.54

30 years (Klimo, Vavříček 1991), we noted that pH values of upper soil horizons under autochthonous beech stands were higher as compared with spruce stands and that podzolic soils were more acid as compared with Cambisols. On the basis of these findings we stated that the process of soil acidification occurred in the Beskydy Mts. as a part of long-term pedo-genetic processes in relation to soil-forming factors, that the process was also affected by changes in the species composition of stands or by changes in logging technologies and recently, the process was accelerated by increased inputs of deposits from the atmosphere.

When we studied the correlation between the rate of soil acidification and the degree of damage to spruce stands in the Beskydy Mts. we could not state a close correlation between the two phenomena as demonstrated by the following data.

It means that damage to stands occurred particularly due to the direct effect of air pollution on vegetative organs.

In assessing the causes of forest decline in the Beskydy Mts. it is possible to take into consideration properties of soils as a long-term stress factor.

As for the effect of forest stands on the soil reaction it is possible to state that the effect of spruce monocultures can markedly influence upper soil horizons in the course of about one or two generations and that the increase in acidity of middle and lower parts of the profile can be explained by more intensive effects of acid depositions from the atmosphere. This opinion was presented by Pokorný (1985) in assessing the effect of pollutants on acidification of soils. According to him acidification by acid depositions will be more significant in deeper horizons than in upper markedly humic soil layers.

Generally, it is possible to say that forests in the Czech Republic have already been stressed by man for thousands of years. The settlement of particular regions took place gradually and the remaining forest complexes were subject to very different intensity of exploitation. Activities of man depleted forest ecosystems of nutrients, viz. from sporadic and dis-

Table 4. pH of soil horizons in National Reserve Boubín

Soil horizon	Stand: beech 8, spruce 2		Stand: beech 3, spruce 7	
	pH in H_2O	pH in KCl	pH in H_2O	pH in KCl
L	4.22	3.59	4.13	3.21
F	3.77	3.24	3.72	2.93
H			3.46	2.77
A	3.72	3.24	3.67	2.88
B	4.28	3.97	(B) 4.31	4.08
B	4.55	4.07		
Cd	4.67	4.12	4.40	4.26

Table 5. Correlation between damage of forest stands and soil acidity in the Beskydy Mts.

Degree of damage to forest stand	pH in H_2O of Oh layers	pH in H_2O of A horizons
0	3.53	3.57
1	3.32	3.62
2	3.51	3.65
3a	3.24	3.54
3b	3.34	3.71
4a	3.52	3.64
4b	3.45	3.55

persed felling to large-area deforestation and intensive use of all biomass including forest litter. In some areas, forest grazing was also usual. Currently, when modern logging technologies are used, so-called whole-tree method is also employed. In this method the return of basic cations taken up from soil by the growth of trees is markedly reduced. These cations can neutralize the production of protons and soil acidity can be increased. The amount of biogenic elements lost for forest soil is thus very different. In areas of lower altitudes intensively settled since long ago, it is possible to calculate the depletion of basic cations to amount roughly to 800–900 keq/ha for the given period. Negative impacts on the condition of forest soils were observed particularly in soil-forming substrates poor in nutrients mainly in northern and western parts of the Czech Republic.

Air pollution

The importance of the factor has to be assessed from the long-term aspect. Information on coal mining the combustion of which was the main source of air pollution in the territory of the Czech Republic for the whole one century has been available since 1880. Since that time, in total 7 milliard t of brown coal and bituminous coal were mined in the region of Bohemia and Moravia. If we take into consideration the average sulphur content and other factors affecting emissions and if we consider emissions from the combustion of other fossil fuels, then the atmosphere above the CR was stressed by about 130–140 million t SO_2 in the past 150 years.

Considering potential dispersion into the environs and, on the other hand, the contribution of foreign sources it is possible to estimate that the average deposition of sulphur per 1-ha area of the CR is 8 t for the past ca. 120 years. It indicates a huge stress corresponding to 500 keq. H^+/ha. It is also necessary to add the fallout of nitrogen compounds, nevertheless, any appraisal for a longer time would not be supported; the rate of stress is, however, markedly increased.

This is however a total estimate, the stress of particular regions significantly differs from the value particularly under conditions of limited dispersal with low chimneys of larger pollution sources by the last mid-century. The stress of soils under forest stands also significantly differs from the general average where the level of dry and wet deposition is fundamentally affected by the character of soil surface and stand and by the course of weather and is liable to extremely high spatial and time variability.

Tall chimneys have decreased the stress in the immediate proximity of pollution sources, however, they increased background air pollution by SO_2 reaching as many as 20 µg SO_2/m^3 (long-term average) on the considerable area of the CR. On ridges of the Krušné hory Mts., annual means reached 120 µg, in foothills even 150 µg SO_2/m^3, which corresponded to about 65–80 kg S/ha per year as dry deposition only. Differences in wet deposition further increase differentiation in the stress of particular regions. In spite of this, however, it is not possible to notice differences in the condition of soils corresponding to the stress differentiation. It is very important that in the course of the 90s of the last century, emissions of sulphur compounds were substantially reduced to about 236 kt SO_2 (as of 2002), i.e. ca. 15% of the highest emissions of the mid-80s.

The most stressed area in the Czech Republic and obviously also in Europe is the region of the Krušné hory Mts. and, therefore, we mention it as an extreme example.

The development and condition of surface soil layers in the Krušné hory Mts.

Northwestern Bohemia, and from the viewpoint of forestry mainly the Krušné hory Mts., has been one of the most stressed regions in Europe already since the mid-nineteenth century. Large sources of air pollution are located in the area where brown coal is mined and processed on the Bohemian side, however, a great part of pollution affecting forests on the mountain ridges also came from north-west. Therefore, extraordinary attention was paid to decrease emissions from sources affecting the whole region. This endeavour has been successful. Sulphur dioxide emissions from large sources in the territory of the CR affecting the Krušné hory Mts. ridges decreased by 77% in the course of the 90s. The fact was also markedly reflected in the pollution stress of the mountain forests. Thus, at the end of the 90s, the period was finished when the direct effect of SO_2 was a critical factor for the development of health conditions of forests in the region. It is therefore possible that consequences of the huge long-term pollution stress of soils of the Krušné hory Mts. will manifest themselves more markedly.

Because the soil has always been the basis of forest production, it is very desirable to answer a question if it is possible to prove the direction and degree of changes which occurred due to the deposition in forest soils in this country and particularly in the Krušné hory Mts. It is important because conclusions will also affect methods and urgency of the solution. Unfortunately, the first sporadic results of chemical analyses of soils on our side of the Krušné hory Mts. are only from the period when marked and extensive damage to forest stands occurred on mountain ridges at the end of the 50s of the last century (Němec 1952). That means in the period when the pollution stress lasted there for at least one century. The development of soils began to be studied methodically by the Institute of Forest Management on a series of soil profiles particularly in more damaged areas of the eastern Krušné hory Mts. since the end of the 70s. It was the period when the stress culminated. Thus, the results of 15-year studies cannot represent the whole development of soil conditions under the impact of air pollution but they can indicate developmental trends under conditions of heavy stress.

The second set of information is based on the results of a survey carried out by the Central Institute for Supervising and Testing in Agriculture the objective of which is to determine the condition of upper soil layers in the Krušné hory Mts. as a basis for soil reclamation measures and for the regeneration of forest stands. The first one occurred in the period 1993–1994, when the stress of the region already began to decrease. It makes possible to make comparisons with situations in other natural forest areas in the territory of the CR, i.e. in substantially less stressed regions.

Tables 6, 7 and 8 show the mean values of analyses of soil samples obtained in 19 soil probes. As anticipated, high to extreme acidity reaches to a large depth, and only at a depth below 1 m acidification decreases. Particularly the development of calcium concentration expressed by means of both 20% HCl and 1% citric acid is remarkable. In the course of 15 years, the trend of decrease is quite evident in all horizons and in both extraction agents. If we assess the results of the stronger extraction agent, a loss from the whole soil profile corresponds to 11,000 kg Ca/ha (ca. 690 keq./ha), i.e. 730 kg Ca (46 keq/ha/a) in the period 1979–1994. It refers to a very large loss, however, it is necessary to take into consideration a considerable content of stones in soils of the Krušné hory Mts. which substantially reduces the total loss after conversion per area. In none of the other studied elements (with the exception of Al) such losses occur.

The results of a survey which was carried out in l994 primarily in the eastern part of the Krušné hory Mts. are the second set of information on the condition of soils in this very stressed area.

Table 6. Development of soil reaction – pH KCl, range in particular horizons by years

Year	Soil horizon				
	Organic horizon	A	E	B	B/Cd
1979	2.76–3.79	2.55–3.44	2.45–3.59	2.67–3.80	3.41–4.09
1984	2.62–3.86	2.65–3.51	2.56–3.93	2.62–4.09	3.36–4.09
1989	2.65–4.11	2.60–3.60	2.53–4.01	2.62–4.99	3.47–4.82
1994	2.79–4.14	2.64–3.53	2.65–3.80	2.72–4.11	3.46–4.10

Table 7. Development of calcium concentration in soil profiles, 20% HCl extract, mean values (%)

Year	Soil horizon				
	Organic horizon	A	E	B	B/Cd
1979	0.421	0.295	0.209	0.191	0.219
1984	0.349	0.200	0.090	0.079	0.092
1989	0.314	0.164	0.152	0.099	0.106
1994	0.256	0.104	0.089	0.101	0.090

Table 8. Development of calcium concentration in soil profiles, 1% citric acid extract (mg/kg)

Year	Soil horizon				
	Organic horizon	A	E	B	B/Cd
1979	1,198	674	368	354	349
1984	1,085	522	484	218	255
1989	1,332	550	194	137	195
1994	1,003	307	184	165	175

Samples of forest floor and surface layers of mineral soil in 120 stands were processed. Results from the Krušné hory Mts. are compared with results of a similar survey which continued in the next years in important natural forest areas of the Hercynian region in the CR (Table 9).

There are no significant differences in the distribution of particular classes of acidity between both sets. In classes up to pH (KCl) 3.0, i.e. in classes of the highest acidity, a smaller number of samples from the Krušné hory Mts. is classified as against other regions of the CR. It is possible to suppose that it is a certain positive result of liming. It was also demonstrated in the markedly higher representation of samples in classes over pH (KCl) 5.1. There are not any very marked differences in the concentration of nitrogen and potassium. The Krušné hory Mts. humus is distinctly poorer in phosphorus, calcium and particularly magnesium and also manganese. However, it is rich in iron, copper and particularly aluminium and lead. The anthropogenic origin of lead in the organic horizon is unquestionable.

Even in the mineral soil there are no significant differences in the exchangeable soil reaction, the pH median in KCl in both sets is virtually the same (pH in KCl 3.35 and 3.36).

There are also no significant differences in nitrogen concentration.

There are no marked differences in the representation of samples in particular concentration classes of extractable potassium. It also corresponds to the representation of elements in the humus layer.

The results of analyses of the content of calcium corroborate that mineral soils are markedly poor in calcium in the Krušné hory Mts. Only a somewhat higher proportion of samples from the region in all classes of Ca concentration indicates effects of liming.

There are marked differences in the distribution of magnesium concentration frequencies in particular classes unfavourable for the Krušné hory Mts. Samples from the mountains are distinctly poorer.

Differences in the concentration of zinc and copper are not very marked. On the other hand, mineral

Table 9. Results of analyses of soil samples of selected natural forest regions in the CR and in the Krušné hory Mts. (KH), frequency distribution in particular classes (%)

pH KCl			Calcium (mg/kg)		
Organic horizon	CR	KH	Organic horizon	CR	KH
–2.4	1.3	0.7	–500	8.8	15.5
–2.7	14.7	5.4	–2,000	36.9	49.2
–3.0	27.0	30.5	–3,500	15.3	11.5
–3.3	19.4	23.6	–5,000	8.6	3.4
–3.6	15.4	10.1	–6,500	6.4	3.4
–3.9	8.3	9.5	–8,000	5.4	3.4
–4.2	2.9	1.3	–9,500	5.1	2.0
–4.5	3.1	2.7	–11,000	3.3	0.7
–4.8	2.0	0.7	–12,500	2.9	0.7
–5.1	1.8	2.7	–14,000	1.7	0.7
> 5.1	4.1	12.8	> 14,000	5.6	9.5

soils from the Krušné hory Mts. are markedly richer in extractable aluminium and iron. (Median for Fe: 9,777 mg/kg Fe samples from the Krušné hory Mts. and 4,962 mg/kg from the CR, for Al 5286 as against 3,374 mg/kg).

It appears that the crucial expression of changes and differences which are significant for the Krušné hory Mts. is changes and differences in Ca and Mg concentrations in soils.

A decrease in the initial reserve of calcium (in 20% HCl extract) amounting to 40% during 15 years is very high exceeding inaccuracies originating during sampling.

There is a very marked difference in calcium concentrations between surface layers of soils in the Krušné hory Mts. and forest soils in other regions of the CR: it is unfavourable for the Krušné hory Mts.

It corresponds to previous findings. Discrepancies between the results of the survey and a fact that the affected region was limed mean that the measure was insufficient to compensate for the depositions and it is necessary to suppose increased movement of calcium in the soil profile owing to acid depositions. Increased movement of the element in soils of the Krušné hory Mts. was found out and published by Lochman (1993, 1996). It is however also possible to fall back on results of experiments with intentional acidification (Klimo et al. 1999). In these experiments studying the movement of calcium, magnesium, potassium, sodium, nitrate nitrogen and sulphate sulphur, calcium and sulphur were washed out most. The addition of sulphur onto the soil surface induced an increased loss of calcium amounting to 32% at 100 kg S/ha (corresponding to 6 keq H^+), at a higher rate corresponding to 300 kg S (19 keq), calcium decreased by 122% as compared with the control. The loss of other elements was lower. In magnesium, the addition of 300 kg S/ha increased the loss of the element by 48%, in potassium by 58% during 5 years. The loss of nitrate nitrogen and sulphates also increased.

If we convert the loss of calcium to the probable level of acid deposition, the loss determined in soil profiles of the Krušné hory Mts. is roughly comparable with the experiment. If we compare calcium concentrations in soils of the Krušné hory Mts. with concentrations which ought to be in them after the application of dolomitic limestone, then we can see a discrepancy. Interpretation of differences (with respect to both previous results) by the shift of calcium to deeper layers of the soil profile owing to acid deposition is realistic. There are also other facts which can influence the balance. First, there are no reliable checks and records what has actually got to the soil surface through liming. If the given doses were actually applied, how much material was dispersed in the vicinity and to what extent the present condition is influenced by the fact that a part of the material was in coarse fractions (up to 4 mm and even more). Though these fractions are not lost, if they do not disintegrate they are thrown away at the preparation of material for analyses using a 2 mm sieve.

Thus it is evident that due to the high air pollution stress, soils of the Krušné hory Mts. are depleted particularly of calcium, total reserves of the element are very low in them and the fact can be an obstacle for the regeneration of vital stands of suitable species composition. Nevertheless, this is not a new finding. It is only the corroboration of findings mentioned by Wieler in his "Entkalkungsteorie" at the beginning of the last century and what was gradually forgotten and newly revived by Ulrich et al. (l981).

Gradually becomes the primary problem of stand nutrition particularly in the western part of the Krušné hory Mts. If we assess the results of needle analyses of Norway spruce, blue spruce and other species, magnesium nutrition is not in order even in the eastern part. Research results positively demonstrate that soils in the Krušné hory Mts. are markedly poorer in this element (extract Mehlich II) than in the other parts of the CR. Thus, the results prove a fact that the first condition of the occurrence of marked defects in Mg supply in the Krušné hory Mts. is fulfilled. However, it refers to a complex problem and, therefore, the occurrence of defects is not related only to low concentrations of Mg in soil.

CONCLUSIONS

Acidification of forest soils in the Czech Republic is a long-term process which is induced by natural and anthropogenic factors.

The character of parent rocks and the species composition of forest stands are main natural factors.

Effects of forest management (changes in the species composition of forests in favour of spruce monocultures and increased use of the biomass of forest stands).

Effects of the input of acid depositions into forest ecosystems which caused particularly increased losses of calcium and magnesium in air-polluted regions.

Forest soil stress caused by air pollution was different in various regions of the CR.

Acidification of soils in the CR and its consequences for their chemistry mostly work as a predisposition factor. It can unfavourably affect the condition of forest ecosystems in relation to other factors.

References

KLIMO E., KULHAVÝ J., PRIETZEL J., REHFUESS K.E., 1999. Impact of simulated acidification and liming on forest soil and Norway spruce (*Picea abies* Karst.) seedling growth in a container experiment. Ekologia (Bratislava), *18*: 413–430.

KLIMO E., VAVŘÍČEK D., 1991. Acidifikace a vápnění lesních půd v Beskydech. Lesnictví, *37*: 61–72.

LOCHMAN V., 1993. Pollutant fall-out into forest ecosystems as related to changes in forest soils. Lesnictví-Forestry, *39*: 58–72.

LOCHMAN V., 1996. Vliv imisních spadů do lesních ekosystémů u Moldavy v Krušných horách na chemismus vody, odtékající do zdrojů. Lesnictví-Forestry, *42*: 437–448.

MAŘAN B., 1944. Půda jako základ lesní tvorby. Písek, Matice lesnická: 544.

MAŘAN B., KÁŠ V., 1948. Biologie lesa. Praha, Melantrich: 596.

NĚMEC A., 1952. Příspěvek k otázce smrku v Rudohoří se zřetelem ke kouřovým škodám. Práce VÚL, *1*: 167–227.

POKORNÝ P., 1985. To the problem of forest soils acidification in Mountain Regions of the CSR. In: KLIMO E., ŠÁLY R. (eds.), Air Pollution and Stability of Coniferous Forest Ecosystems. Proceedings of the Symposium, October 1–5, 1984. Brno, University of Agriculture, Institute of Forest Ecology: 81–91.

WIKLANDER L., 1978. The sensitivity of soils to acid precipitation. In: HUTCHINSON T.C., HAVAS M. (eds.), Effects of Acid Precipitation on Terrestrial Ecosystem. Proceedings of the NATO Conference, Toronto, Ontario, May 21.–27. NATO Conference Series, Series I.: Ecology. New York, London, Plenum Press.

ULRICH B., MAYER R., KHANA P., 1981. Deposition von Luftverunreinigungen und ihre Auswirkungen in Waldoekosystemen im Soling. Forstl. Fak. Univ. Goettingen. Frankfurt am Main, Sauerlaenders Verlag.

ZLATNÍK A. et al., 1938. Průzkum přirozených lesů na Podkarpatské Rusi. Brno, Sborník výzkumných ústavů zemědělských ČSR, sv. 152: 524.

Acidifikace lesních půd v České republice

E. Klimo[1], J. Materna[2], V. Lochman[2], J. Kulhavý[1]

[1]*Lesnická a dřevařská fakulta, Mendelova zemědělská a lesnická univerzita v Brně, Brno, Česká republika*

[2]*Výzkumný ústav lesního hospodářství a myslivosti, Jíloviště-Strnady, Česká republika*

ABSTRAKT: Poškozování a odumírání lesních porostů v České republice vyvolalo i nutnost objasnit funkci půdy v těchto procesech. V práci jsou posouzeny hlavní faktory mající vliv na acidifikaci lesních půd. Jsou to na jedné straně faktory přírodní – vlastnosti půdotvorných substrátů, druhová skladba lesních porostů, a na druhé straně vlivy antropogenního charakteru – působení člověkem založených smrkových monokultur a pak působení kyselých depozic. Zvláštní pozornost je věnována vývoji lesních půd v Krušných horách, kde byl vliv kyselých depozic nejvyšší.

Klíčová slova: acidifikace lesních půd; přírodní a antropogenní vlivy

Poškozování a odumírání lesních porostů v České republice vyvolalo i nutnost objasnit vztah mezi vstupem imisí do prostředí lesa, změnami půdního prostředí a poškozením až odumíráním lesních porostů, zejména smrkových. Půda v rámci lesního ekosystému má převážně dost stabilní vlastnosti i v závislosti na dlouhodobém charakteru její geneze. Ovšem destrukce tohoto subsystému může znamenat až kolaps lesního ekosystému jako celku.

Z hlediska acidifikace lesních půd na území ČR musíme uvažovat několik faktorů:
– charakter půdotvorných substrátů,
– druhovou skladbu lesních porostů,
– vstup kyselých imisí do půdního prostředí.

Obecně můžeme konstatovat, že uvedené faktory mají spíše aktivní podíl na acidifikačních procesech lesních půd. Samozřejmě jsou významné rozdíly v jejich působení v jednotlivých regionech v závislosti na kombinaci faktorů prostředí. Bezprostřední působení acidifikačního procesu na stav lesních ekosystémů je ještě více komplikovaný, protože zde působí další faktory, jako jsou epizodické změny klimatu (změny teplot, období sucha apod.).

Samotný proces acidifikace vyvolává v lesních půdách zejména vyluhování bazických kationtů Ca a Mg a půda v procesu poškozování až odumírání lesních porostů působí jako dlouhodobý stresový faktor. Dlouhodobě může na procesy acidifikace působit i způsob hospodaření v lese, jako je totální odebírání biomasy dřevin a s tím i narušení návratu bází odebíraných v procesu růstu z půdy a jejich odebírání např. při holopasečné obnově lesa a celostromové těžbě dřeva.

Cílem práce bylo dokumentovat komplexní pohled na procesy acidifikace lesních půd v ČR a tím napomoci lepšímu porozumění úlohy půdy při odumírání lesních porostů.

Corresponding author:

Prof. Ing. Emil Klimo, DrSc., Mendelova zemědělská a lesnická univerzita v Brně, Lesnická a dřevařská fakulta, Lesnická 37, 613 00 Brno, Česká republika
tel.: + 420 545 134 038, fax: + 420 545 211 422, e-mail: tesarjar@mendelu.cz