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Does the understory affect cation exchange capacity and aluminium solubility in acid soils under spruce forest stands?

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Coniferous tree stands are known to have an acidifying effect on the soil and influence Al compounds transformations. It was also ascertained that the type of forest understory (domination of Alpine lady fern or bilberry) affects the course of pedogenic processes expressed by a quality of humus and the mobility of Fe and Al within the Carpathian subalpine spruce forest stands (West Carpathians, Southern Poland). Therefore one can suppose that these understory types influence also cation exchange properties. The aim of the work was to check the hypothesis by explaining differences in pH, effective cation exchange capacity (CEC_e) and Al forms in soils of the two understories. Sampling was done from A horizons of fern soils (20 samples) and from AE horizons of bilberry soils (20 samples). All studied soils were derived from sandstone and were located under similar physiographic conditions.

Mean SOM content and CEC_e values were higher in A horizons under fern (78.8 gkg^{-1} and 148.4 $mmolkg^{-1}$) than in AE horizons under bilberry (66.1 gkg^{-1} and 125.6 $mmolkg^{-1}$), respectively. Mean pH_{H2O} was the same in both soil groups amounting to 3.9, while pH_{KCl} was slightly higher in soils under fern (3.0) than under bilberry (2.8). However, regardless of the understory type soil pH was below the threshold pH value ($pH_{threshold}$ = 6.06-0.47pH_{KCl}) ranging from 4.4 to 4.8. It indicated that in studied soils pH solution was controlled by chemisorption of Al to soil organic matter. In acid, organic matter-rich forest soils, with a low amount of clay minerals the value of pH solution is often described by the Bloom and Grigal equation: $pH=pK_{app}+ n Log((BS_e)/(1-BS_e))$, where pK_{app} stands for the negative logarithm of the apparent dissociation constant, n is an empirical stoichiometry constant of the reaction, BS_e is the effective base saturation, i.e. the fraction of the effective cation exchange capacity (CEC_e) neutralized by base cations (Ca^{2+}, Mg^{2+}, K^+, Na^+). Thus, 1-BS_e refers to the fraction of exchangeable acidity (H_e+Al_e). This equation took forms: pH_{KCl} = 4.821+1,699*log((BS_e)/(1-BS_e)) with r=0.790, and pH_{KCl} = 1.531–1.051*log((BS_e)/(1-BS_e)) with r=-0.865, respectively for A horizons under fern and AE horizons under bilberry. A negative correlation between pH and BS_e/(1-BS_e) found in soils under bilberry can be explained only by an alkaline reaction of Al_e which in the equation was included in the exchangeable acidity. Humus horizons under fern contained organic compounds with a higher dissociation constant (4.821), thus weaker organic acids, than the ones under bilberry (1.531). Lower deprotonation of SOM in fern soils resulted also in smaller CEC_e/C_t fraction (3.22) than in SOM under bilberry (3.40). Soils under fern were characterised by a higher amount of Al_p but a lower fraction Al_e/Al_p(about 0.5) than soils under bilberry (0.72). The differences in Al binding to organic matter resulted probably from a lower amount of fulvic acids determined in SOM under fern (36.1%) than in soils under bilberry (41.02%). It means that the Alpine lady fern in the understory of spruce forests increases complexation/precipitation of Al and in this way reduces its potential toxicity.