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STUDIES ON SOME FACTORS AFFECTING THE QUANTITATIVE ESTIMATION OF THE EXCHANGE CAPACITY OF ORGANIC MATTER[1]

Abstract

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METHODS which are satisfactory for determining the base-exchange capacity of mineral soils can not be applied indiscriminately for determining the exchange capacity of fresh or decomposed plant residues. Preliminary investigations on undecomposed tree leaves, peat moss, and forest humus layers indicate that:

1. The exchange capacity of organic residues varies with the cation used for saturation of the exchange complex, e.g., the exchange capacity in M.E. per 100 grams for sumac leaves saturated with various cations was as follows: $NH_4 = 16.9$; $Mg = 67.6$; $Ba = 76.3$; and $Ca = 101.2$. The differences in M.E. of Mg, Ba, and Ca absorbed by the other plant tissues included in these studies were not so striking as for sumac. The absorptive capacity, however, of organic residues for ammonium was found in all cases to be considerably less than that for the divalent cations. The differences noted in the absorptive capacity of organic matter, particularly fresh tissue, is probably due to the multiplicity of compounds active in the absorption and to differences in the solubility of the various absorption products.

2. Exchangeable barium can be replaced with NH_4Cl, $NH_4C_2H_3O_2$, $Mg(C_2H_3O_2)_2$, and HCl, precipitated as barium chromate and satisfactorily determined volumetrically by determining the chromium iodometrically. However, consistently high results for exchange capacity based on barium absorption were found when the barium was replaced with $Ca(C_2H_3O_2)_2$. Working with solutions of known barium concentrations it was found that in the presence of considerable calcium that recovery of barium in all cases exceeded the theoretical amount present. This error can be eliminated by a double precipitation of the barium. Procedures involving the saturation of organic matter with barium and its subsequent replacement with calcium acetate[3] or any other soluble calcium salts are not considered as giving reliable results for the exchange capacity of organic matter by the writers unless a double precipitation of the barium is carried out.

3. Water-soluble substances present in plant tissues contribute toward their exchange capacity. The removal of these substances from tissue prior to its saturation is accompanied by a decrease in exchange capacity. The decreases observed were greater for tissue subsequently saturated with divalent cations than when saturated with ammonium.

4. The initial leaching of plant residues with ammonium salts to replace their exchangeable bases and subsequent saturation of the tissue with a divalent cation results in a lower exchange capacity than if the tissue had initially been saturated with the divalent cation. It would appear that the base exchange capacity and replaceable bases of plant residues and forest humus horizons should be determined on separate samples.

5. Repeated alternate saturation of undecomposed long-leaved pine, peat moss, black walnut and tulip poplar tissue with barium and ammonium revealed a steady positive increase in the absorptive capacities of these tissues for ammonium. No significant changes in the absorptive capacities for barium were observed. The probable cause of this phenomenon and its possible relationship to the lower absorptive capacity of plant tissue and forest humus horizons for ammonium in comparison with divalent cations will be discussed in a forthcoming paper.

6. The ash residue of tissues ignited at 300°C absorb considerable quantities of barium which can be replaced by ammonium. However, upon washing the ash free of excess ammonium salts, it was found that no ammonium had been absorbed during the replacement reaction. The writers are of the opinion that the exchange capacity of plant ash is not due to zeolitic materials as has been suggested but rather to a reaction between the calcium carbonate surfaces of the ash and the barium saturating solution. The barium carbonate formed at these surfaces is dissolved rather than replaced by the ammonium solutions.

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[3]Millar, H. C., Smith, F. B., and Brown, P. E. A method for determining the exchange capacity of organic matter in the presence of nitrogen and calcium. Proc. Iowa Acad. Sci., 43: 161–167. 1936.