Al chemistry in acid forest soil organic horizons

Operationally defined extractions

Table 1. Extraction procedures used.

Abbreviation	Extractant	Sample Condition	Solution:Soil Ratio	Time	Reference
				h	
Ba	0.1 *M* $BaCl_2$	Moist	20 mL:2 mL	2	Gillman and Sumpter (1986)
KCl	1.0 *M* KCl	Moist	20 mL:2 mL	2	Barnhisel and Bertsch (1982)
Choline	1.0 *M* choline-Cl	Moist	20 mL:2 mL	6H0.5	Tucker (1985)
La	0.2 *M* $LaCl_3$	Moist	20 mL:2 mL	2	Bloom et al. (1979)[H]
Cu	0.5 *M* $CuCl_2$	Moist	20 mL:2 mL	2	Jou and Kamprath (1979)
Pyro.	0.1 *M* Na-pyrophosphate	Dry	30 mL:0.3 g	16	McKeague (1967)
Oxalate	0.3 *M* NH_4-oxalate, pH 3	Dry	10 mL:0.25 g	4	McKeague and Day (1966)
Total	HF digestion	Dry	100 mL:0.025 g		Lim and Jackson (1982)

[H] modified from 0.33 *M*

48 Oa and A horizon samples from various research sites in ME, NH, NY and VT

Table 2. Range in chemical characteristics of the horizons sampled (*n* = 48 except where noted).

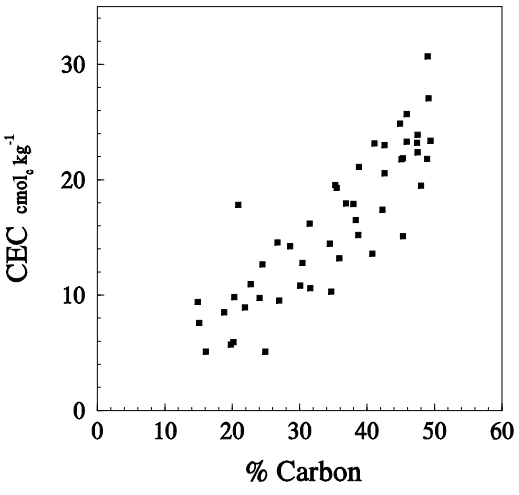
		min	max	median
Carbon	%	14.9	49.4	36.4
pH in 1 mM $CaCl_2$		2.77	4.19	3.29
CEC	$cmol_c\ kg^{-1}$	5.10	30.70	16.35
Exchangeable Ca^{2+}	$cmol_c\ kg^{-1}$	0.17	17.04	4.22
Exchangeable H^+	$cmol_c\ kg^{-1}$	0.18	14.41	3.59

Aluminum extracted by:		min	max	median
0.1 *M* $BaCl_2$	mmol kg^{-1}	4.6	68.8	23.1
1.0 *M* KCl^H	mmol kg^{-1}	8.2	78.6	30.3
1.0 *M* choline-Cl^H	mmol kg^{-1}	5.2	78.8	27.6
0.2 *M* $LaCl_3$	mmol kg^{-1}	11.5	178.7	47.9
0.5 *M* $CuCl_2$	mmol kg^{-1}	14.6	412.4	59.1
0.1 *M* Na-pyrophosphate	mmol kg^{-1}	17.4	770.1	92.9
0.3 *M* NH_4-oxalate, pH 3	mmol kg^{-1}	22.1	941.1	88.4
HF digestion	mmol kg^{-1}	182.9	2176.3	902.8

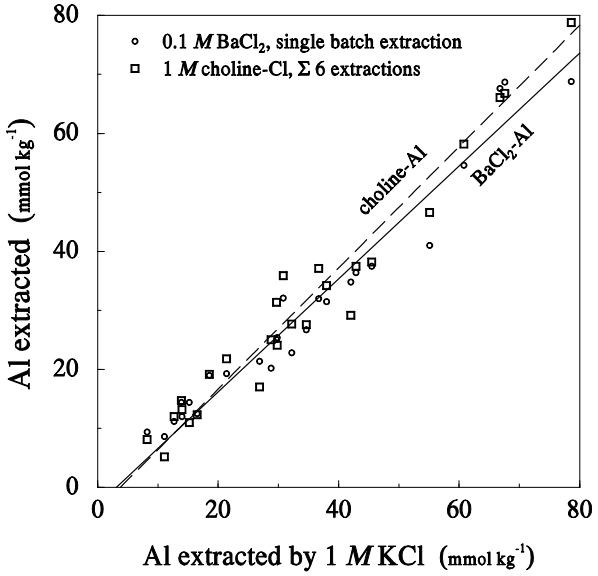
^{H} *n* =26

CEC is related to carbon content and not pH. Although, the carbon content is somewhat correlated with pH (lower pH = higher C)

Figure 2. C vs. CEC in northeastern Oa horizons



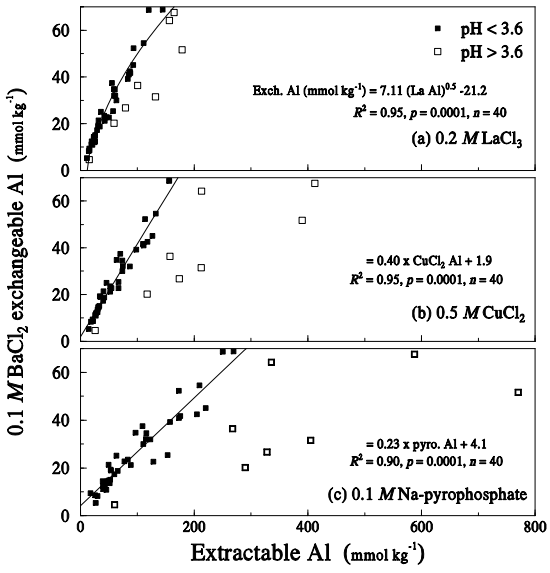
"Exchangeable" Al can be extracted by any neutral salt as long as the concentration is relatively high and the solution:soil ratio is relatively wide.
Choline is an organic cation that should only have electrostatic interactions and only replace truly exchangeable cations.



Stronger extractants have been used to estimate different forms of Al.

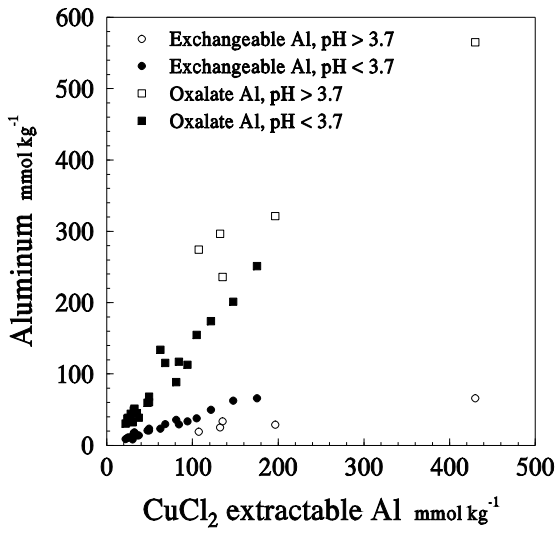
Cu^{2+} is strongly sorbed by soil organic matter and has been used to estimate organically bound Al.

Pyrophosphate has been used to extract organically bound Fe and some use it for Al.

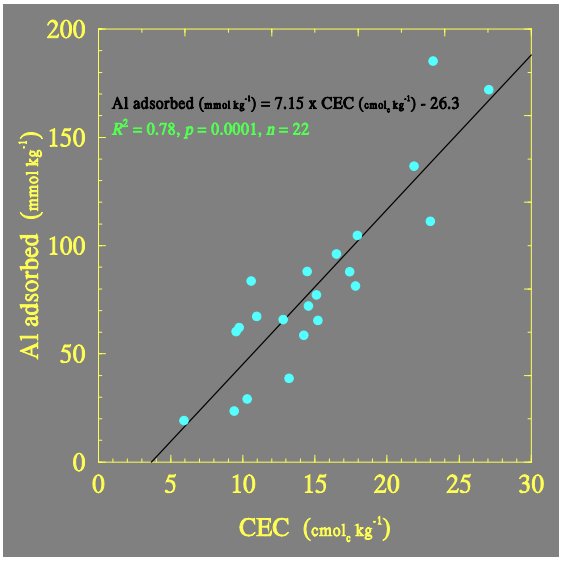


Ammonium oxalate has been used to extract amorphous forms of Fe oxides. Some have used it for Al.

Figure 8. Forms of Al in Oa horizons



Added Al is adsorbed proportionally to the soil's CEC even though the amount sorbed exceeds the CEC



Charge Fingerprint method for CEC determination

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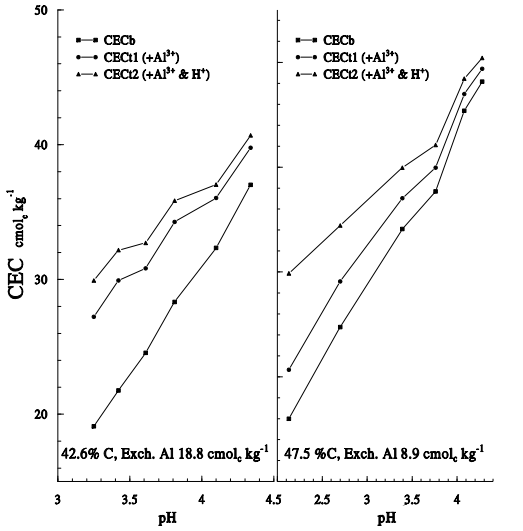
1. Extract with 0.1 *M* $CaCl_2$
2. Equilibrate with 2 *mM* $CaCl_2$
3. Adjust different samples to a range of pH with $Ca(OH)_2$ or HCl
4. Adjust conductivity to desired ionic strength
5. Weigh, and extract Ca and Cl with 1 *M* NH_4NO_3
6. Calculate CEC from the final Ca and Al extracted.

Figure 9. Charge Fingerprints of Two Examples Oa Horizons



Charge Fingerprints of Oa Horizons

During the procedure Al will reoccupy a portion of the exchange sites. The sorbed Ca represents the CECb (base cation CEC). The Ca and Al represent the total CEC (CECt). Acid organic soils will also have a portion of the CEC occupied by H^+.