SOIL ACIDITY AND ITS SIGNIFICANCE IN FOREST FERTILIZATION

by

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Joseph Baker*

ABSTRACT

In a laboratory study, the initial effects of urea applications on the soil acidity of three Vancouver Island soils were investigated. Initially, the three soils differed greatly in their acidities, both in regard to exchangeable and titratable forms. As a result, their responses to urea also differed rather markedly. Exchangeable acidity in both surface mineral and litter materials of all three soils was substantially reduced by the neutralizing effect of urea. With reference to titratable acidity, the sample soils responded quite differently to urea. The litter samples of Port Renfrew and Woss Camp were little influenced by the treatment, while that of Jeune Landing was considerably reduced. In the surface mineral soils, titratable acidity of the Port Renfrew sample was decreased, while that of Woss Camp was untouched. The surface mineral soil of Jeune Landing had neither type of acidity present.

A soil leaching-titration technique is described which is simple to perform and the results of which provide an adequate basis for deciding the kind and amount of fertilizer to be applied.

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INTRODUCTION

Forest species, particularly conifers, unlike agricultural crops that usually require soils with pH values between 6 and 7 for optimum growth, are frequently found on soils that are considerably more acid. Wilde, (1958) suggested that the optimum soil pH range for conifer seedlings is between 5.0 and 5.5.

Artificial fertilization is increasingly becoming an important facet in forest management programs. Since nitrogen is the fertilizer most frequently applied, and as it may initiate either alkaline or acid side reactions within the soil, depending on the form applied, the choice of fertilizer carrier for a given soil becomes a most important matter. The various forms of nitrogen usually applied are urea, ammonium nitrate, and ammonium sulfate; but, as Holman (1969) suggested, these should not be used indiscriminantly on soils with widely differing properties. The selection of the nitrogen carrier demands a considerable knowledge of the chemical properties of both the carrier and the soils. To avoid possible adverse effects, the chemical properties of both fertilizer and those of the soil on which it is to be applied, should be compatible so that no undesired alterations of pH or nutrient availability takes place.

To evaluate the effects of urea, an initially alkaline producing compound, on some of the exchange and acid properties of soils, a laboratory study was undertaken using samples from a site on which certain field studies had been carried out, (Baker, 1969, 1970a, 1970b).

The following report describes some of the effects of urea on the acid properties of the sample soils. A soil titration technique, designed to quickly furnish information regarding the important exchange properties of soils is also described. The technique provides a means of deciding both the source and rate of application of nitrogen required. Recommendations suggesting suitable fertilization programs for the soils of each area have been given.

METHODS

Soil samples from three locations on Vancouver Island, Port Renfrew, Woss Camp, and Jeune Landing were taken from the litter surface, the 0-4, 4-8, and 8-12 inch depths. All litter materials were air-dried and passed through a 5 mm sieve, while the mineral soils were sieved through a 2 mm screen. Soil columns (Figure 1), were constructed in such a way that the sequence of soil layers were maintained. Treatments of 0, 400 and 800 pounds N per acre as urea-nitrogen were applied to the surface of each column and the contents wetted with distilled water to approximately capillary capacity. Leachates were returned to the column. The columns were covered with watch glasses and allowed to stand for 6 weeks. During this period, sufficient water was added to the columns to maintain them in a moist condition. Upon completion of the 6-week period, the columns were dismantled and the soil from each layer examined separately.

Titrations of exchangeable and titratable acidity* were carried out on 0.5 g and 1.0 g samples of litter and mineral soil respectively. Three titrations per sample were performed. Samples of the unleached and leached soil as well as the potassium chloride extract were titrated. The KCl-extracts were obtained by passing 150 ml of molar potassium chloride through the soil sample (Figure 2). Titrations were carried out on control, urea-treated, and aluminum-saturated samples. The aluminum-saturated samples were obtained by leaching the soil with a 10% solution of aluminum sulfate and removing excess aluminum salt by water-washing.

All titrations were performed on a E436 Metrohm self-recording potentiograph using either 0.04 N calcium hydroxide or 0.04 N hydrochloric acid as the case required. Soil-potassium chloride suspensions were kept agitated during titration by a magnetic stirrer, and pH measurements were made by glass-calomel electrodes.

A preliminary experiment was undertaken to determine the most efficient method for removing salt-extractable acidity. In the usual agitation-centrifugation method, a known weight of soil is repeatedly extracted by a given volume of salt solution. The sample is first agitated, then centrifuged, and the supernatant solution decanted. In the continuous-leaching method the weighed sample of soil was maintained in a V-shaped plastic funnel by placing a piece of absorbent cotton in

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*Exchangeable acidity is removed by leaching a soil with a neutral unbuffered salt solution such as normal KCl. Titratable acidity is non-exchangeable in neutral salt solution but is titratable with base solutions such as Ca $(OH)_2$ or Ba $(OH)_2$ and is usually evaluated at pH 8.2.

the neck of the funnel (Figure 2). To prevent undue agitation of a soil sample during the wetting and extraction processes, a plastic disc was placed over the soil before additions of water or potassium chloride. Sufficient time was permitted to thoroughly wet the sample before the salt extraction was undertaken. Water was added to wet, but not to leach the sample. At the beginning of the leaching process 10 ml portions of molar potassium chloride were added frequently, but as leaching progressed, larger volumes were added. A total of 150 ml of solution were passed through each sample.

RESULTS AND DISCUSSION

Extraction Method

Figure 3 compares the initial pH of the leachate and the acidity extracted by molar potassium chloride by the two extraction methods. Since the continuous leaching method removed more salt extractable acidity, this porcedure was used throughout the study. This difference may be due to complex ion-exchange and hydrolysis reactions and to the readsorption of hydrolyzed groups, particularly monomeric aluminum ions (Coleman, 1967). Exchange acidity removed by neutral unbuffered salt solutions, according to Coleman (1967) and Wiklander (1964), is due almost entirely to monomeric trivalent aluminum ions. Partially neutralized aluminum ions may be readsorbed as non-exchangeable groups so that the full acid potential of complete hydrolysis is not developed. In the continuous-leaching procedure, reactions products are quickly removed and the possibility of readsorption of partially neutralized aluminum or hydroxy-aluminum groups, is decreased.

This may account for the difference in the acidity extracted by the two methods.

Exchange Acidity Characteristics of Sample Soils

Initial pH values of the 4-8" and 8-12" layers in molar potassium chloride were above 5, suggesting little or no exchange acidity in these samples. The discussion regarding exchange acidity in the sample soils is confined to the litter surface and the 0-4" surface mineral layer samples where pH values were much lower. Although soils in unbuffered salt solutions, with pH values greater than 5, have little exchange acidity they often have considerable non-exchangeable or reserve acidity (Pratt and Blair, 1962).

Titration curves are given for the unleached and leached samples and for the associated leachate of the surface litter and mineral materials of the three locations (Figure 4). These curves reveal that not only the total, but also the proportion of exchangeable to non-exchangeable or titratable acidity differs in both organic and mineral samples from the three locations. Of the litter samples (4-0"), only that from Port Renfrew exhibits any real exchange acidity (Figure 4 and Table 1). The KCl extract from the litter sample of Woss Camp appears to have much, but the very small inflexion in the curve suggests that little exchangeable monomeric aluminum was hydrolyzed in response to increasing pH values during titration (compare the shape of this curve with that of KH (phth). Possibly the hydrolysis of difficultly exchangeable Al-OH groups is responsible (Coleman and Thomas, 1967). The obvious inflexion in the titration curve of the port Renfrew extract suggests that a considerable proportion of the acidity generated is of the exchangeable form and is due to the hydrolysis of exchangeable aluminum. In contrast, the surface litter from Jeune Landing has little acidity that is either truly exchangeable, or which arises from the hydrolysis of difficultly exchangeable groups. If it may be assumed that acid soils behave as though they had two components of acidity, that exchangeable by neutral unbuffered salt solution and that which is titratable but non-exchangeable, a truer measure of titratable acidity (to pH 8.2) should be obtained from the titration of the soil leached of its exchange acidity. An examination of the titration curves of the salt-leached samples reveals that Jeune Landing litter has a titratable acidity of about one-half that of Port Renfrew which, in turn has less than one-third that of Woss Camp. This more clearly shows the differences in buffer capacity of the three samples.

It has been suggested that unbuffered neutral salt extracts may possibly contain acidity arising from groups other than those that are truly exchangeable. Thus, the titration of the leached sample differentiates between those acid groups removed by unbuffered neutral salt and those that are not. At a given pH value, the sum of the acid groups in both leachate and leached sample do not equal those detected in the unleached sample. The removal of ion complexes capable of hydroxyl polymerization greatly reduces the neutralization capacity of the salt-extracted samples. Jackson (1963) and Raupach (1957) suggested that polymerization of aluminum-hydroxyl units takes place with the formation of ill-defined aluminum-hydroxy groups. The number of hydroxyls within these groups vary per aluminum and the size of the group increases with increasing pH. Wiklander (1964), found in organic matter that oxidation processes as well as the generation of acid groups increase with rising pH. With increasing pH, the unleached sample progressively consumes more base than that used in the combined titrations of leachate and salt-extracted soil. The titration of a soil previously extracted of its exchangeable cations and acid groups, should more correctly estimate of the inherent pH-dependent acidity* to a given pH, (which at 8.2 is virtually the same as titratable acidity) since polymerization of aluminum-hydroxyl groups is reduced. In this respect, at pH 5.5, the Woss Camp litter has over 3 times the pH-dependent acidity of Port Renfrew and about 40 times that of the Jeune Landing litter (Figure 4). Table 1 shows three forms of acidity: salt-extractable (extract), pH-dependent (leached soil), and that which is created during neutralization with a base (Coleman, 1967). Created acidity is the difference between total acidity of the unleached sample and the sum of acidities found in the leached sample and its KCL-extract at a given pH value. For the two strongly acid soils, the summation of exchange acidity and exchangeable bases approximates the effective cation exchange capacity, i.e. that obtained by extraction with neutral unbuffered salt. For a soil that is base saturated, i.e. Jeune Landing, exchangeable bases approximates the cation exchange capacity. Normally, this soil should exhibit characteristics similar to the other two; however, as reported earlier (Baker, 1969) this soil was altered considerably by a heavy burn in 1951.

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* pH - dependent acidity, in this report, refers to the neutralizing capacity of a soil that has been leached free of its exchangeable acidity. It may be evaluated at any pH value from the leached soil titration curve; at pH 8.2 it is essentially similar to titratable acidity. The titration, however, must be carried out in an unbuffered, neutral salt solution.

The discussion relative to the litter samples (4-0") generally is applicable to the surface mineral samples (0-4"). In the mineral samples of both Port Renfrew and Woss Camp however, the exchange acidity makes up a larger proportion of both the total acidity, and effective cation exchange capacity. The Jeune Landing mineral sample, as did the litter, reflects the results of the severe burn to which that soil was subjected. The deposition of ash (mainly as carbonates) during the combustion of fuels, and the subsequent hydrolysis of these virtually neutralized all components of acidity, at least to a depth of 12 inches; pH values of the salt extracts were all well above 7. As a result of regrowth of vegetation, there has been a tendency for the soil to revert to its original state. However, considerable time will be required before normal conditions are restored. Presently, the soil exhibits acid and exchange properties unlike those normally expected for soils of this area.

Source of Soil Acidity

Data given in Figures 5 and 6 and Table 2 suggest that the acidity in the surface mineral soil of Port Renfrew and Woss Camp is due to hydrogen and aluminum. In each case the upper curve (Figure 5) represents the normal acidity extracted by molar potassium chloride. Besides removing the exchange acidity the unbuffered salt also removes exchangeable bases. The lower curve displays the additional acidity removed from the aluminum saturated soils by molar potassium chloride. The increased acidity is due primarily to the occupation, by aluminum, of exchange sites normally satisfied by exchangeable cations in the unleached sample i.e. calcium, magnesium, etc. However, the acidity of the aluminum solution may have freed some exchange sites previously occupied by difficultly exchangeable groups, or it may have dissolved some of the mineral exposing new exchange sites which become occupied by exchangeable aluminum and/or hydrogen. (Seatz and Peterson, 1964). For Port Renfrew and Woss Camp mineral soils, the data (Table 2) suggest that the increased acidity of the aluminum saturated soil is due to the removal of exchangeable bases by the first salt extraction and the subsequent occupation of these exchange sites by aluminum. With the exception of the Jeune Landing sample, which is excessively base saturated, the difference between the two acidity curves at the specified pH values (Table 1) approximates the exchangeable bases.

Similarities between the titration curves of the mineral soil extracts and those of aluminum chloride and potassium acid phthalate (shown in Figures 5 and 6), strongly suggests that acidity in these soils is due to an exchangeable aluminum-hydrogen system. The source of acidity in potassium acid phthalate is hydrogen only whereas in a soil system both hydrogen and aluminum are exchangeable below pH 5.5. When a soil system is titrated, the first increments of base neutralize the exchangeable hydrogen and the shape of the titration curve, especially below pH 4.8, resembles very closely the potassium acid phthalate curve. Above pH 4.8 and with the addition of more base, aluminum begins to undergo hydrolysis to produce hydrogen ions (Seatz and Peterson, 1964). The shape of the aluminum titration curves (Figure 6) and those of the mineral soil KCl-extracts (Figures 4 and 5) especially above pH 4.8 are strikingly similar. As a result it seems justifiable to conclude that in both Port Renfrew and Woss Camp mineral (0-4") samples and Port Renfrew litter, the exchange acidity is due to a hydrogen-aluminum system.

Theoretical Considerations of Acidity

Hydrolysis of Aluminum and Buffer Capacity.

Hydrolysis of the hydrated aluminum ion is responsible, not only for the low pH values, but also for the neutralization or buffer capacity of solutions or suspensions containing such ions. Schofield and Taylor (1954) described the initial hydrolysis of aluminum chloride by measuring pH values of solutions of different concentrations. The reaction for this initial stage of hydrolysis is (Gilreath, 1954):

$$Al(H_2O)_6^{+3} + H_2O \;=\; Al(H_2O)_5\,(OH)^{+2} + H_3O+ \qquad \ldots\ldots \quad (1)$$

Assuming the concentration of water as a constant, the equilibrium expression for the above reaction is:

$$\frac{\left[Al(H_2O)_5\ \ (OH)^{+2}\right]\ \left[H_3O^+\right]}{\left[Al(H_2O)_6^{+3}\right]} \;=\; K_h \;=\; \frac{Kw}{Kb} \qquad \ldots\ldots \quad (2)$$

Since equal amounts of $Al(H_2O)_5\ OH^{+2}$ and H_3O^+ are produced, equation 2 becomes:

$$\frac{\left[H_3O^+\right]^2}{\left[Al(H_2O)_6^{+3}\right]} \;=\; \frac{Kw}{Kb} \qquad \ldots\ldots \quad (3)$$

and equation 3 reduces to:

$$\left[H_3O^+\right] = \sqrt{\frac{Kw}{Kb} \;\times\; \left[Al(H_2O)_6^{+3}\right]} \qquad \ldots\ldots \quad (4)$$

Since Kw is a constant, i.e. 1×10^{-14}, and Kb, for the initial hydrolysis, is 7.1×10^{-10}, $Kw/Kb = 1.41 \times 10^{-5}$ which also is the ionization constant (Ka) of the $Al(H_2O)_6^{+3}$ ion as an acid. Thus equation (4) further reduces to:

$$\left[H_3O^+\right] = \sqrt{Ka \times \left[Al(H_2O)_6^{+3}\right]} \quad \ldots.. \quad (5)$$

Taking negative logarithms of this last expression yields:

$$pH = 1/2\ pKa + 1/2\ pAl(H_2O)_6^{+3} \quad \ldots.. \quad (6)$$

Jackson (1963) suggested that half-completion of the initial stage of hydrolysis of the $Al(H_2O)_6^{+3}$ ion was near pH5. Since the pKa of a half neutralized acid solution is equal to the pH, then the pKa value of the half neutralized $Al(H_2O)^{+3}$ ion, as an acid, is also at, or near 5, at which point the buffer capacity is at a maximum. This is amply shown in the titration of 4×10^{-4} molar aluminum chloride (Figure 6). It is interesting that the same concentration of aluminum chloride in water has the lower initial pH value than that in neutral unbuffered molar salt solution; this may be due to a decrease in hydrolysis of aluminum by the presence of molar potassium chloride, or by a neutralization of some H^+ ions initially produced by hydrolysis. Between pH 5.8 and 6.6, a second small inflexion point may be observed. This probably is due to the second stage in hydrolysis of the hydrated aluminum ion;

$$Al(H_2O)_5\ (OH)^{+2} + H_2O = Al(H_2O)_4\ (OH)_2^{+} + H_3O^{+}$$

While this ionization reaction occurs, it is extremely small.

In addition to the normal titration curves, plots of the first derivative of the titration curve with respect to the volume of base used are also given (Figure 6). These show more clearly the stepwise hydrolysis of the hydrated aluminum ion. Each plateau in the dE/dt curves represents the completion of hydrolysis of the particular ion species; by pH 5.8 the hydrolysis of $Al(H_2O)_6^{+3}$ is completed, by pH 6.6, that of $Al(H_2O)_5\ OH^{+2}$ is complete. Of interest, is the fact that the final stage of hydrolysis adds no acidity to the system and, in fact, precipitation of aluminum hydroxide commences when hydrolysis is two-thirds complete. Coleman and Thomas (1967) reported the precipitation of gibbsite from aluminum chloride at two-thirds neutralization.

Effects of Urea-Nitrogen

Figures 5 and 6 reveal that salt-extracts of the mineral soil of Port Renfrew and Woss Camp possess the inflexion points characteristic of the aluminum chloride in molar potassium chloride solution. This suggests that not only the tivalent, hydrated $Al(H_2O)_6^{+3}$, but also some of the $Al(H_2O)_5\ (OH)^{+2}$ groups are exchangeable by neutral unbuffered salt solution in these soils. However, the concentration of the divalent hydroxy-aluminum ion is virtually negligible compared to that of the trivalent form. Thus, as Pratt and Bair (1962) have reported, the entire exchange acidity of most mineral soils is associated almost solely with the first stage of hydrolysis; this stage, for the soils in question, is completed by about pH 5.8.

The examination of the behaviour of the aluminum ion largely explains the nature of soil acidity, and in particular, the acidity of forest soils. It gives a reason for the low pH values, i.e. about pH 4.5 to 5.0 for most conifer-supporting surface mineral soils. Both Wilde (1958) and Lutz and Chandler (1946) have reported, low pH values of forest soils are not incompatible with high site quality. Thus it becomes important in effective forest management to employ silvicultural practices that do not interfere adversely with the normal equilibrium conditions characteristic of the soil.

The effects of nitrogen applications, as urea, to the soils under question are given (Table 3). Both the surface litter and mineral samples from Port Renfrew show reductions in salt-extractable and the titratable acidity; the greater reduction occurred in the extract of the mineral soil. The heavier fertilizer application produced similar, but greater reductions in exchangeable and titratable acidity. Neither rate greatly influenced the titratable or reserve acidity, of the litter sample.

In the Woss Camp soil, salt-extractable acidity of both litter and mineral surface samples was influenced by the treatment. The litter material was affected to a greater extent than the mineral soil by both rates; this is in direct contrast to the effect shown by the Port Renfrew soil. Reserve or titratable acidity in the Woss Camp soil was unaffected by urea.

The addition of urea to the Jeune Landing samples virtually neutralized any soil acidity that developed since the heavy burn of 1951.

CONCLUSIONS AND RECOMMENDATIONS

From the foregoing, it is apparent that soil systems differ, and as a result will differ in their responses to a given management practice. It is also evident that the exchange and acid properties of the three soils under study are sufficiently different to warrant individual attention rather than a "blanket-type" approach. While the exchange and reserve acid properties of the Woss Camp soil could withstand heavy applications of alkaline producing substances, such as urea, without immediate adverse effects, those of the Jeune Landing and Port Renfrew soil could not. Even the well buffered Woss Camp soil could not withstand indefinitely the heavy, habitual use of urea without adversely modifying the exchange and acid properties normally associated with this soil. With a much greater proportion of the total acidity as the exchange form, the selection and application of nitrogenous fertilizer to the Port Renfrew soil requires considerable care and attention. Excessive use of urea-type fertilizers could quickly alter the natural equilibrium of this soil and thus adversely influence the solubility and availability of essential nutrients.

Any future large scale fertilization program that may be contemplated should give consideration to the possibility of applying nitrogen carriers whose chemical characteristics are compatible with those of soil. Thus for a soil such as that of Jeune Landing, an acid producing carrier, i.e. ammonium sulfate or nitrate, should be used. In contrast, urea, in substantial amounts, may be applied to the highly buffered Woss Camp soil without greatly affecting the natural equilibrium. Soils such as Port Renfrew, with moderate reserve of soil acidity, and which are susceptible to sudden changes in pH and exchange acidity which may affect nutrient availability, require special attention in the selection and application of nitrogen amendments. Perhaps for Port Renfrew and similar soils, the alternate use of acid-and base-producing nitrogen carriers, in a continuing fertilizer program, should be considered.

The approach taken in this study could be of considerable value in future field forest fertilization programs contemplated for areas in which detailed information regarding soil properties may be lacking or deficient. The titration technique, is simple to perform and quickly yields sufficient information regarding those properties likely to be influenced by fertilization. It provides a basis for the proper selection of both kind and amount of fertilizer to be applied.

REFERENCES

Baker, J. 1969. Soil properties and nutritional status of western hemlock tissue from over-stocked stands. Info. Rept. B.C.-X-38. Canadian Forestry Service, Victoria, B.C.

Baker, J. 1970a. Some effects of urea fertilization on soil characteristics and tissue mineral content in over-stocked western hemlock stands. Info. Rept. B.C.-X-39, Canadian Forestry Service, Victoria, B.C.

Baker, J. 1970b. Nitrogen loss from surface-applied urea. Info. Rept. B.C.-X-42, Canadian Forestry Service, Victoria, B.C.

Coleman, H.T., and G.W. Thomas. 1967. The basic chemistry of soil acidity. In Agronomy No. 12. Amer. Soc. of Agron. Madison, Wisc.

Gilreath, E.S. 1954. Qualitative Analysis Using Semi-micro Methods. McGraw-Hill Book Co. New York.

Holmen, H. 1969. Forest fertilization in Sweden. Forestry Chron. Vol. 45 (p. 239).

Jackson, M.L. 1963. Aluminum bonding in soils. Soil Sci. Soc. Amer. Proc. 27: 1-10.

Lutz, H.J., and R.F. Chandler. 1946. Forest Soils. John Wiley & Sons. New York.

Pratt, P.F., and F.L. Bair. 1962. Cation exchange properties of some acid soils of California. Hilgardia 33: 689-706.

Raupach, M. 1957. Investigations into the nature of soil pH. Commonwealth Sci. & Ind. Res. Organ. Soil Pub. 9. Melbourne. (Cited from Agronomy No. 12, Amer. Soc. Agron., Madison).

Schofield, R.K., and A.W. Taylor. 1954. The hydrolysis of aluminum salt solutions. J. Chem. Soc. 18: 4445 - 4448.

Seatz, L.F., and H.B. Peterson. 1964. Acid, alkaline, saline, and sodic soils. In Chemistry of the Soil. Reinhold Publishing Corp. New York.

Wilde, S.A. 1958. Forest Soils - Their Properties and Relation to Silviculture. The Ronald Press Co. New York.

Wiklander, L. 1964. Cation and anion exchange phenomena. In Chemistry of the Soil. Reinhold Publishing Corp. New York.

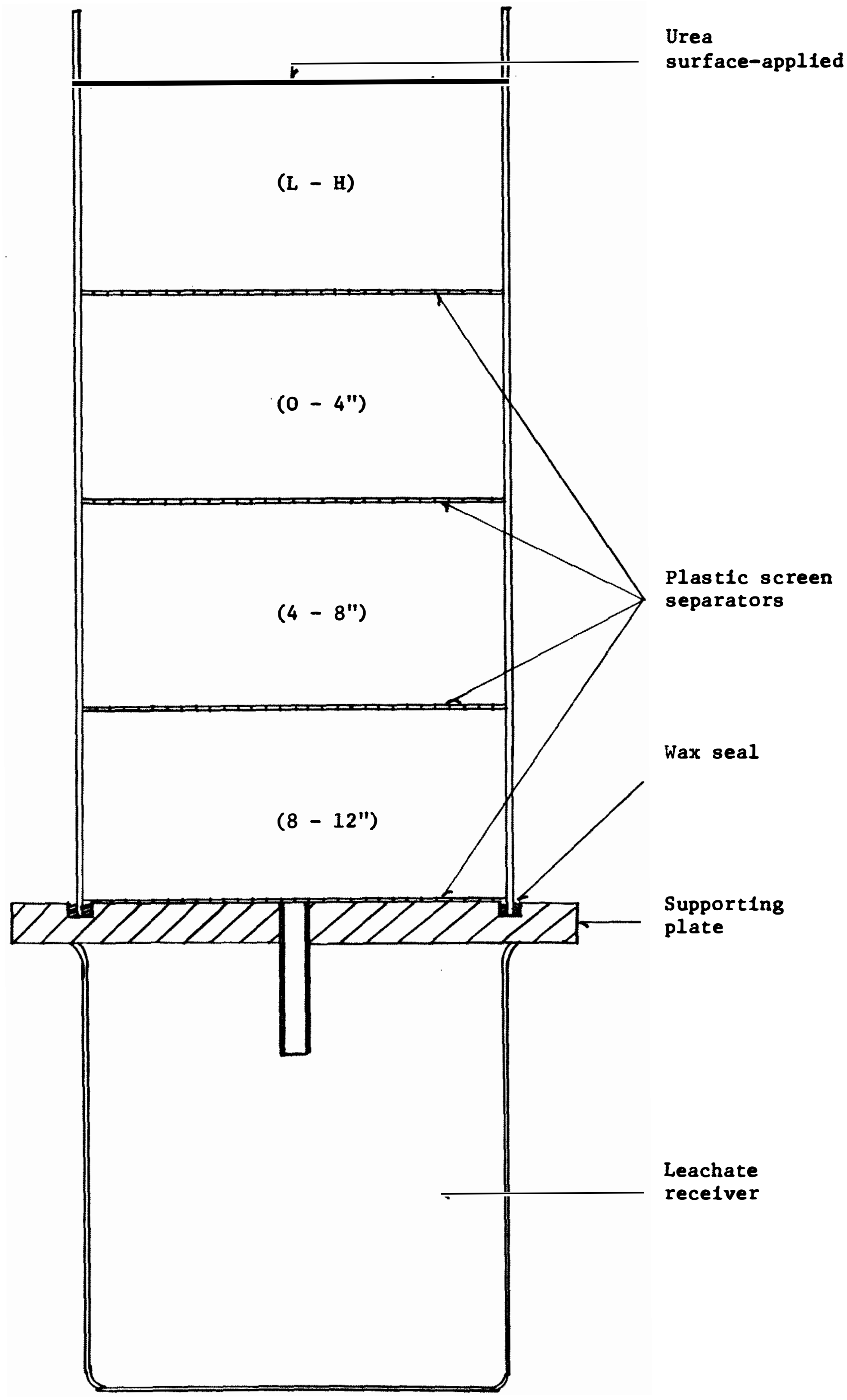

Figure 1 - Diagram of soil column

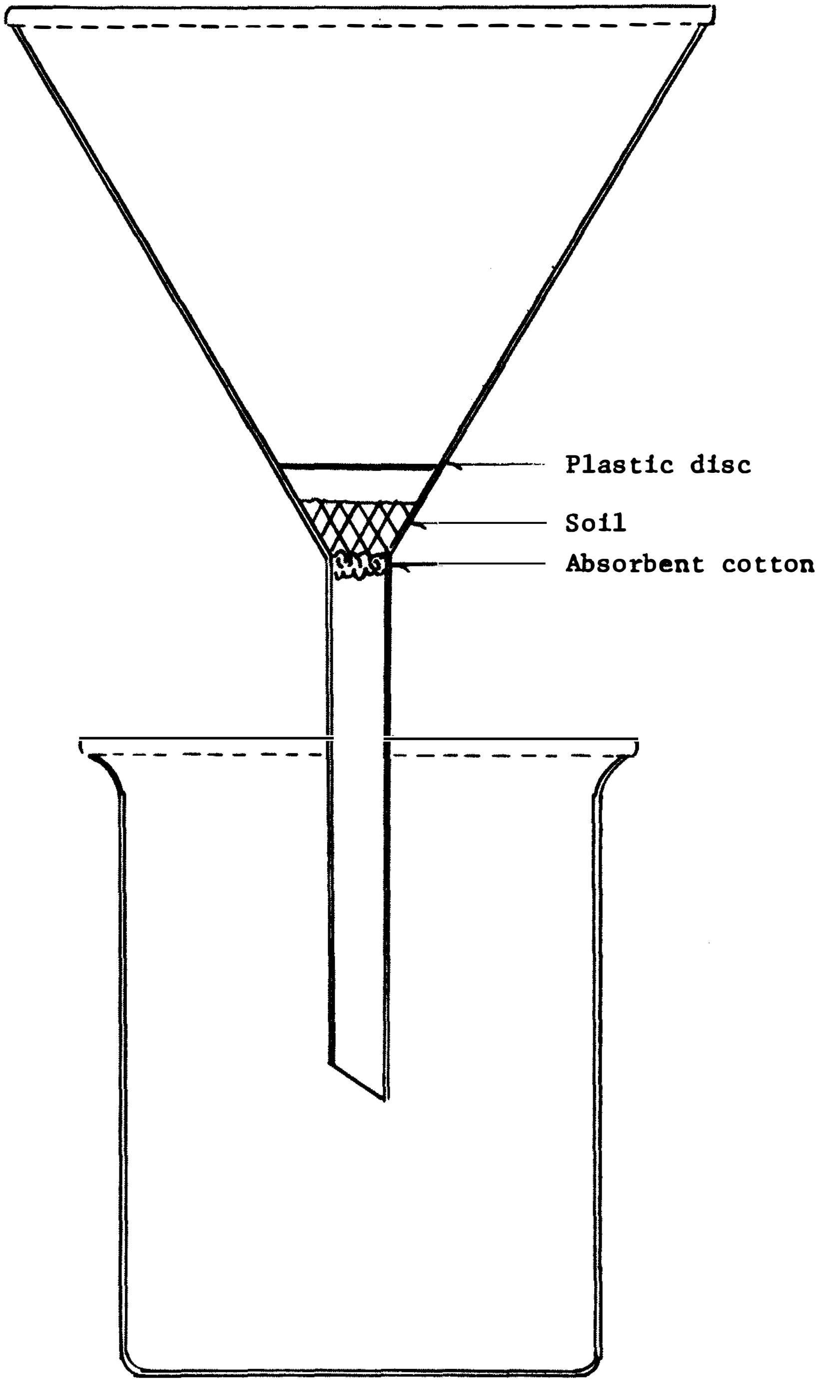

Figure 2 - Diagram of leaching apparatus

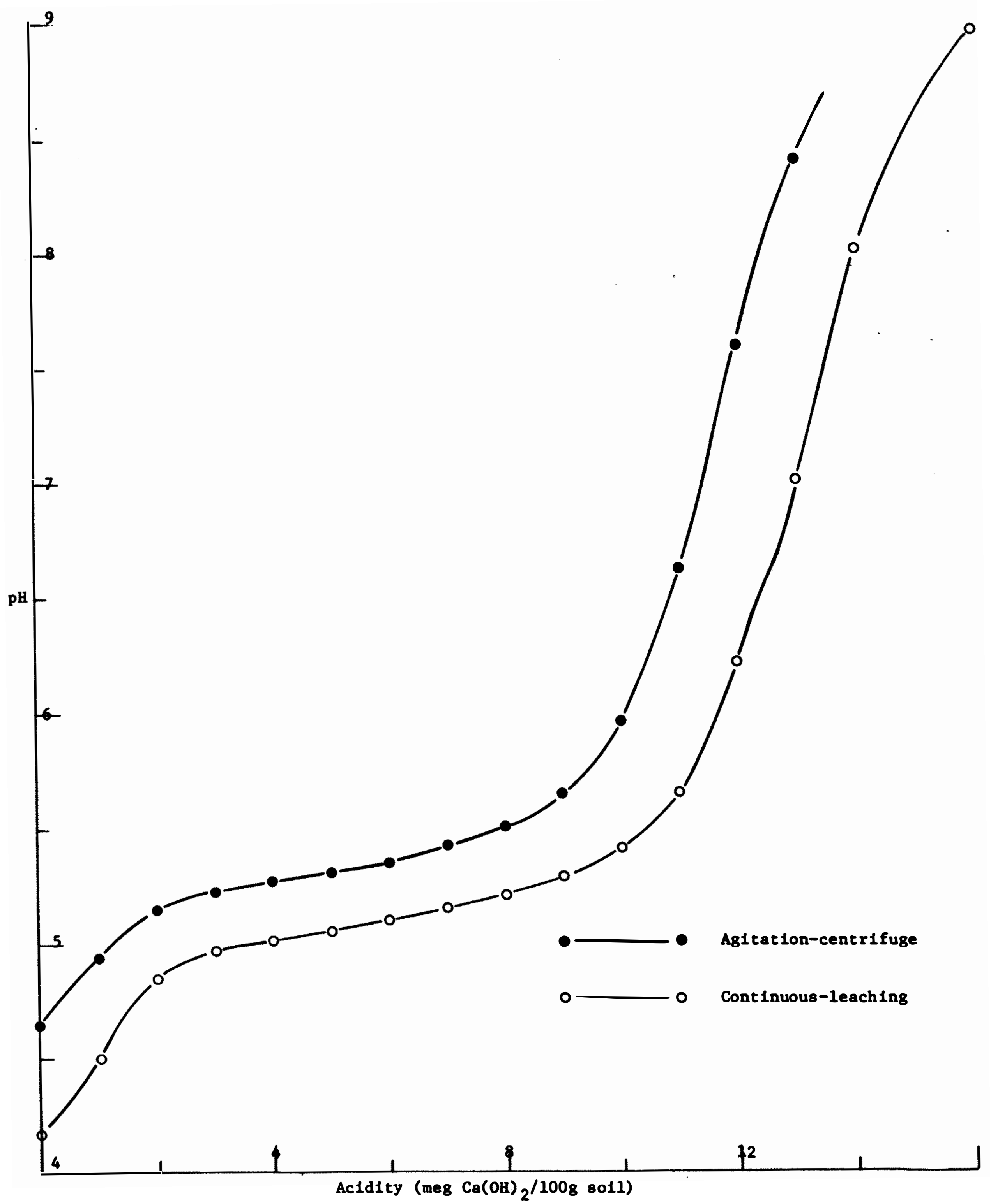

Figure 3 - Salt-extractable acidity (mKCl) from the surface mineral soil (W.C. 0-4") by the methods indicated.

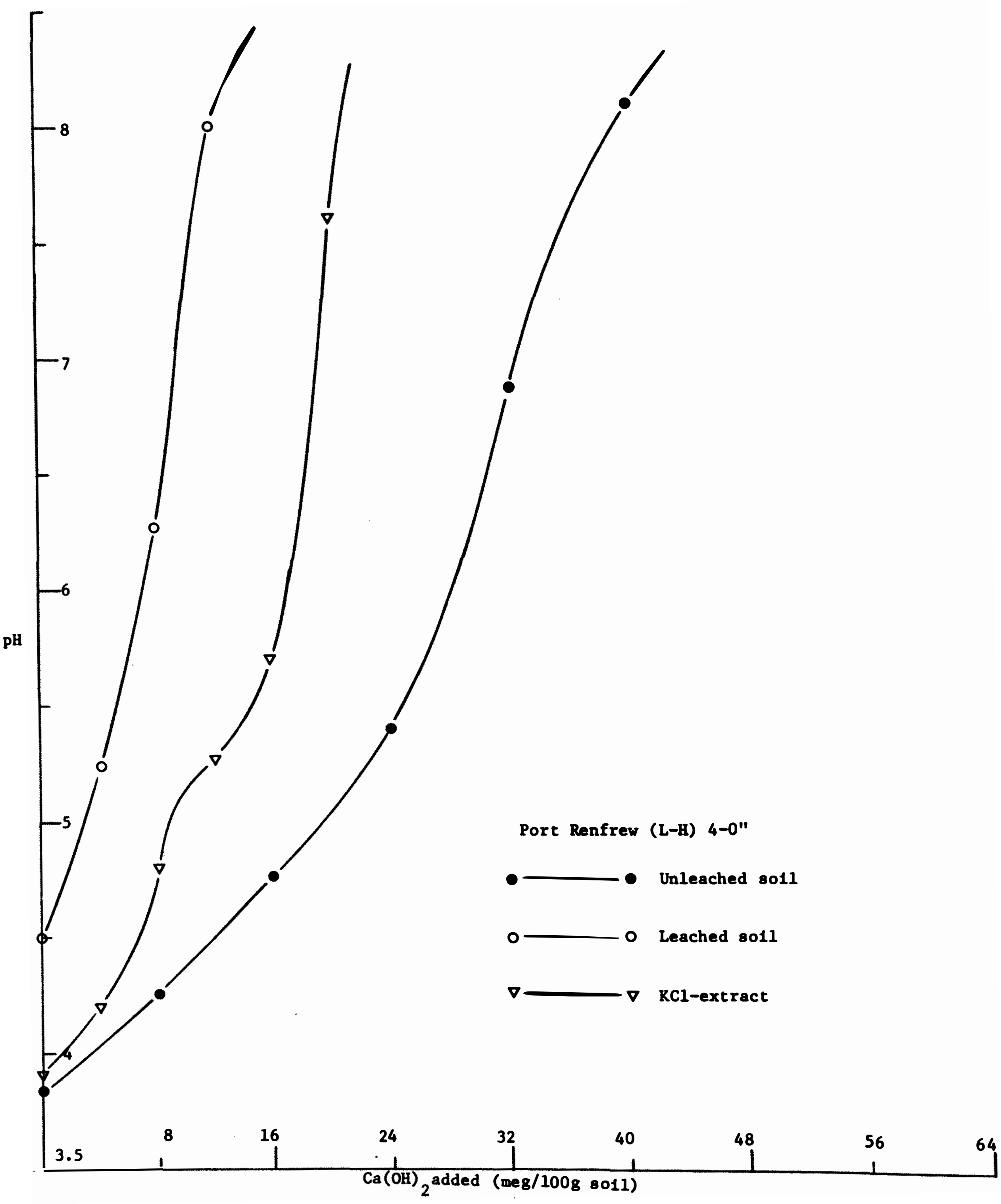

Figure 4 - The differentiation of soil acid by titration with standard calcium hydroxide/Port Renfrew (L-H) 4-0"

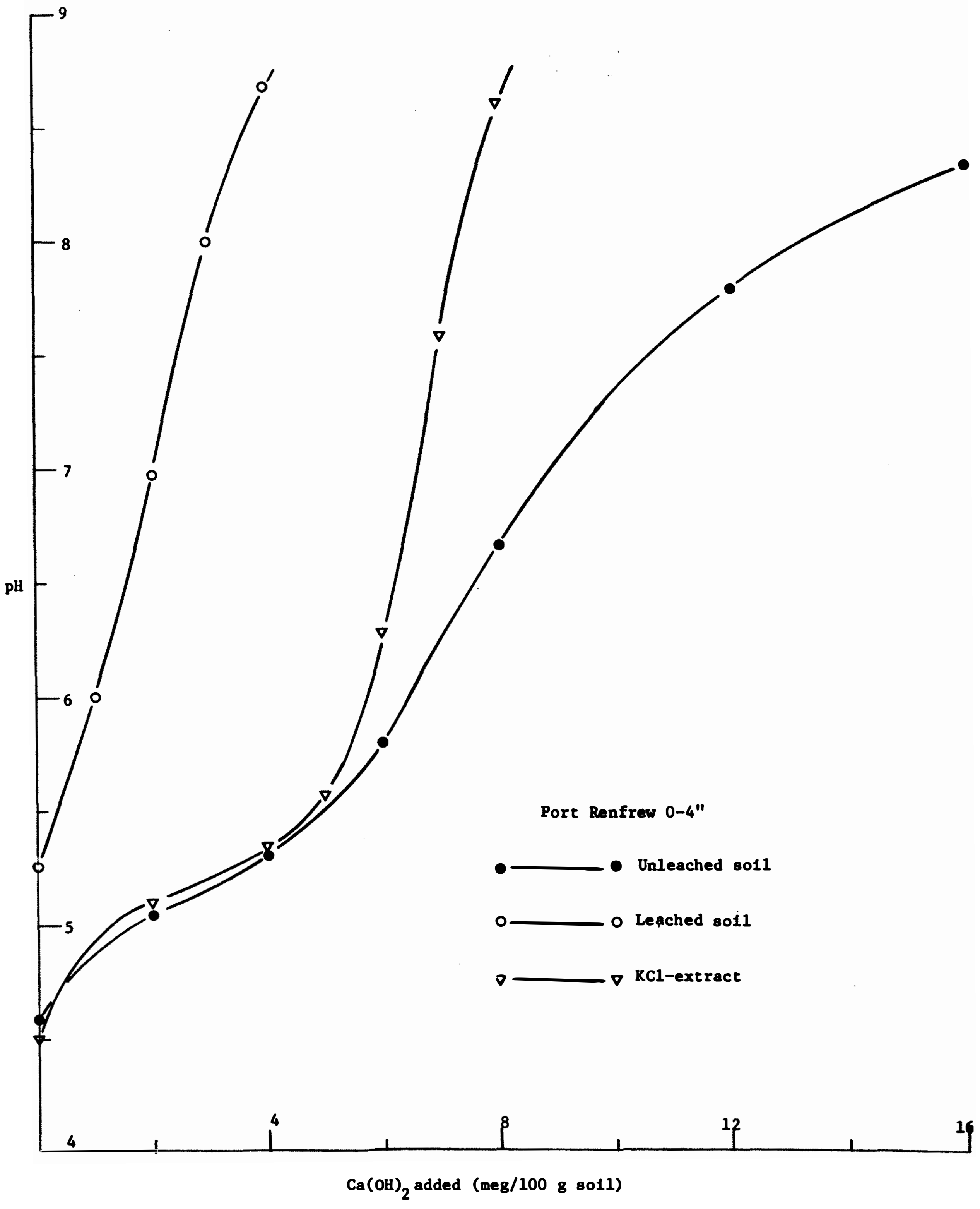

Figure 4 - Continued/Port Renfrew 0-4"

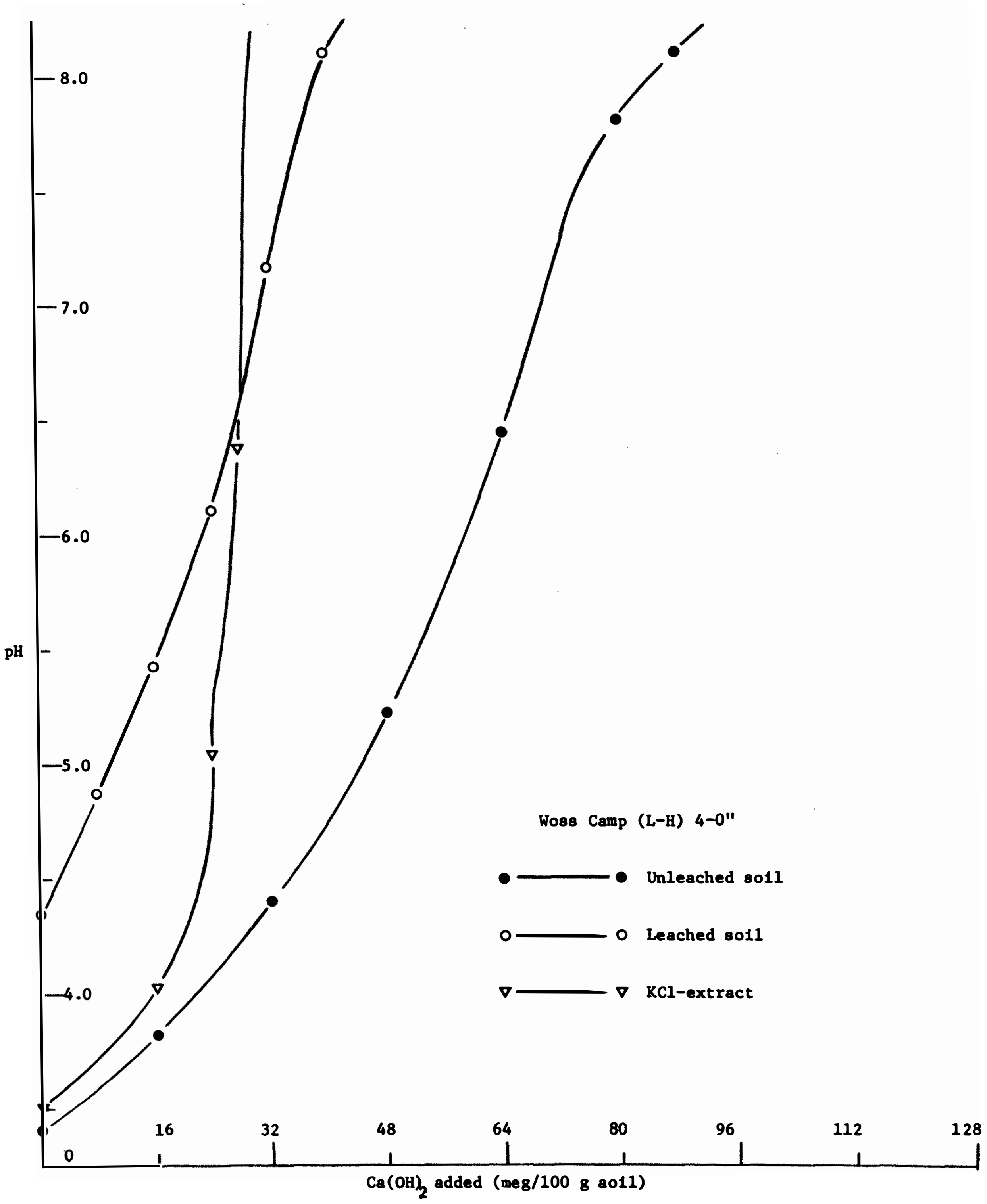

Figure 4 - Continued/Woss Camp (L-H) 4-0"

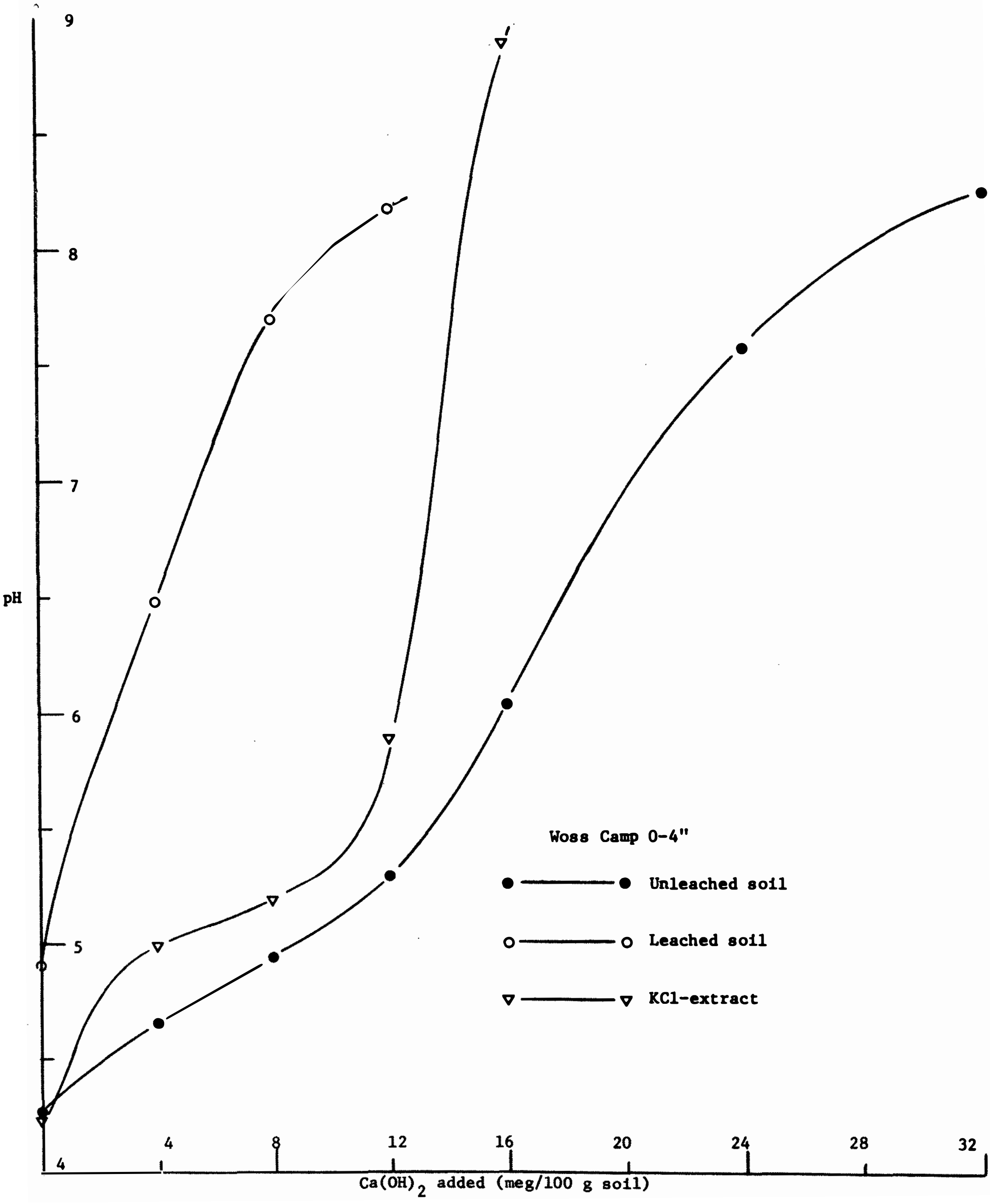

Figure 4 - Continued/Woss Camp 0-4"

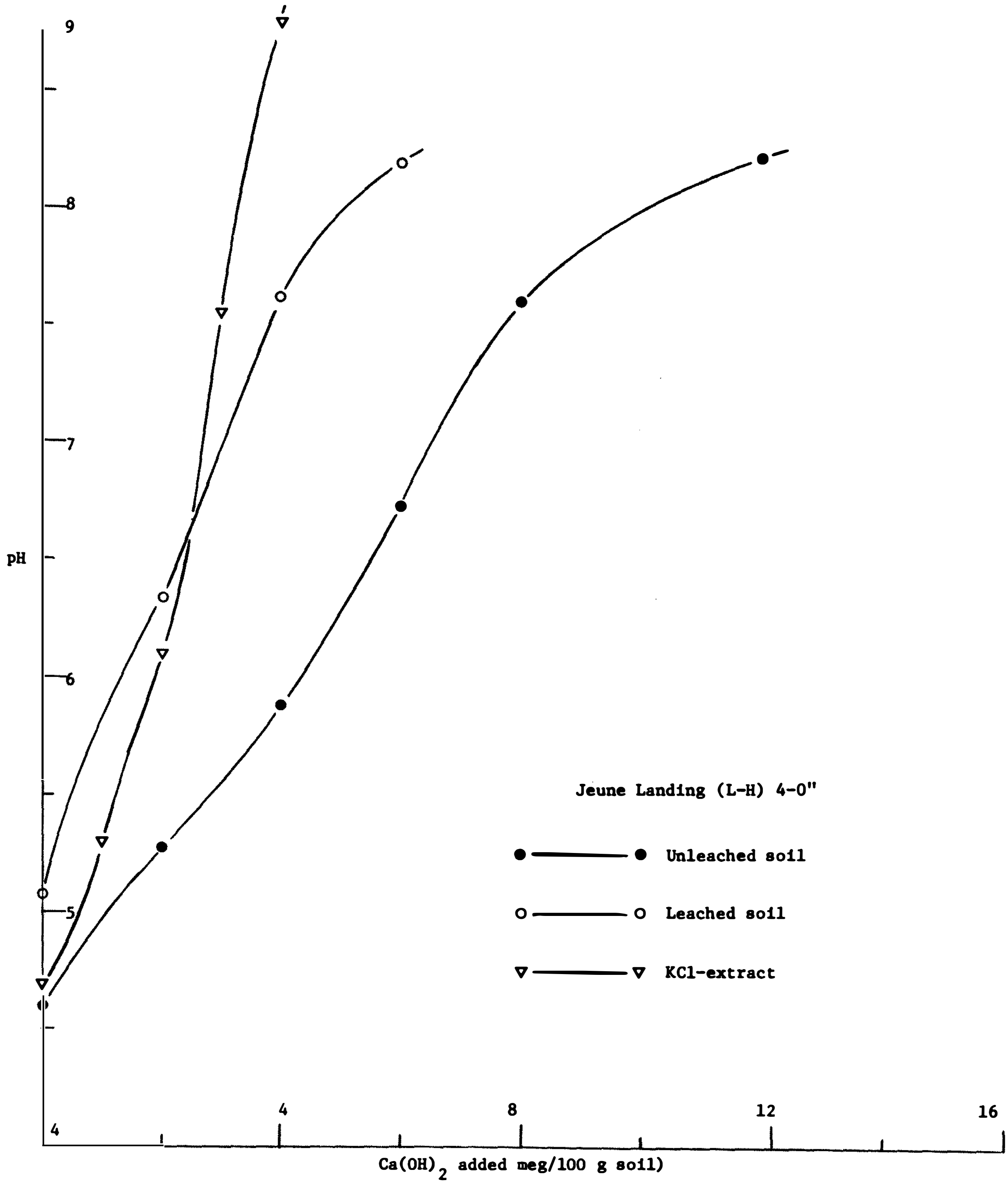

Figure 4 - Continued/Jeune Landing (L-H) 4-0"

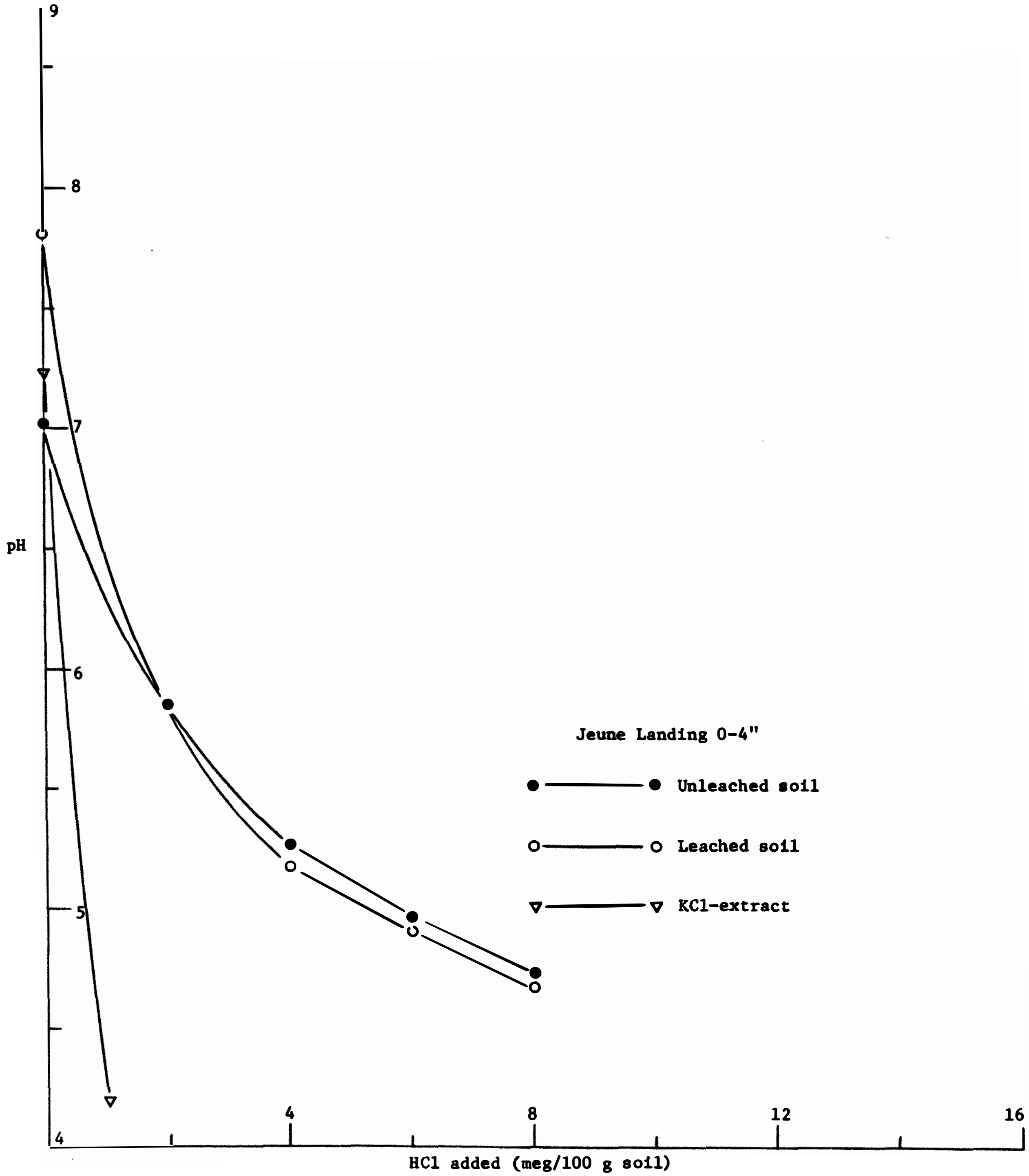

Figure 4 - Continued/Jeune Landing 0-4"

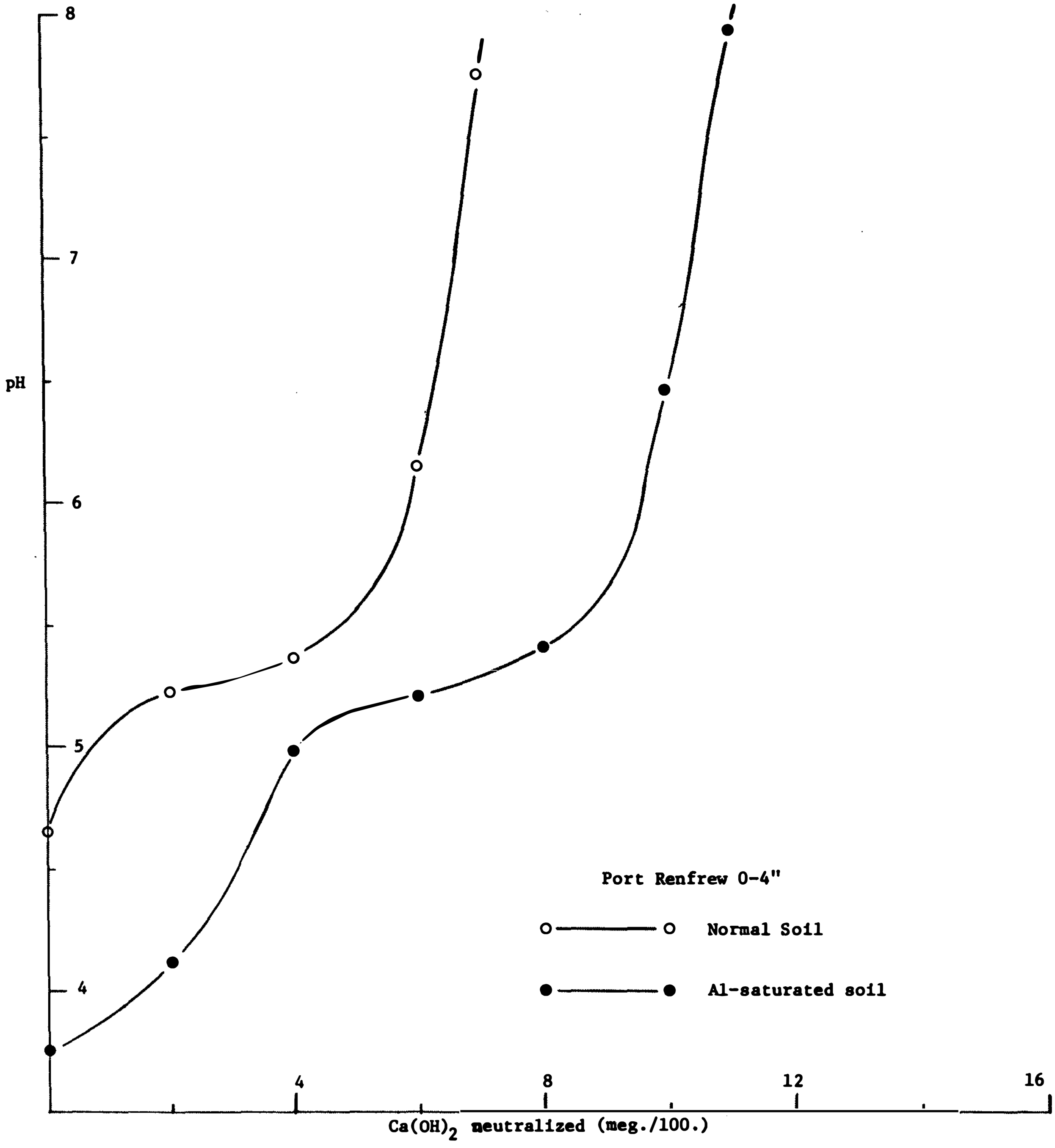

Figure 5 - Acidity removed from a surface mineral soil before and after aluminum saturation/ Port Renfrew 0-4"

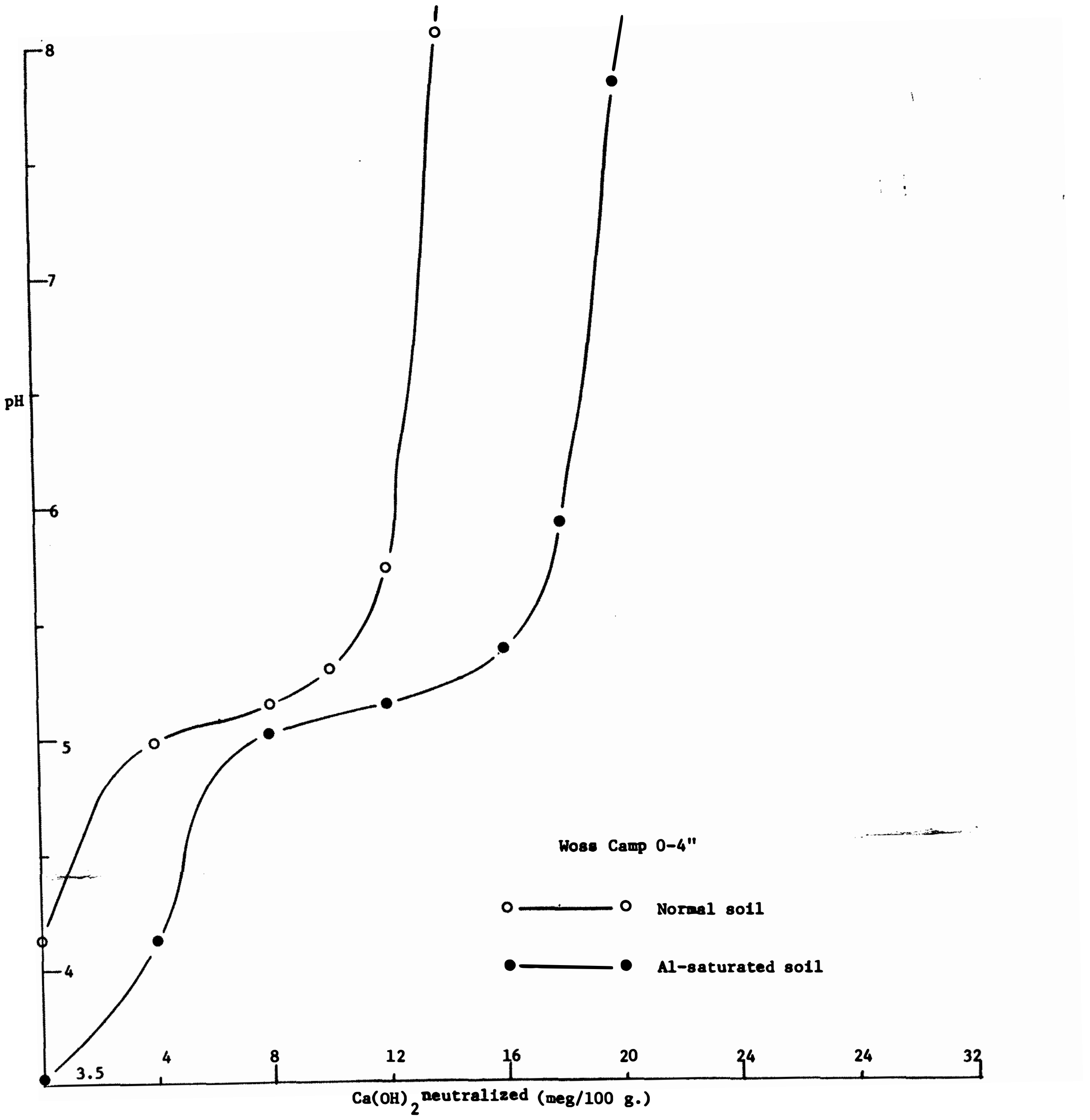

Figure 5 - Continued/Woss Camp 0-4"

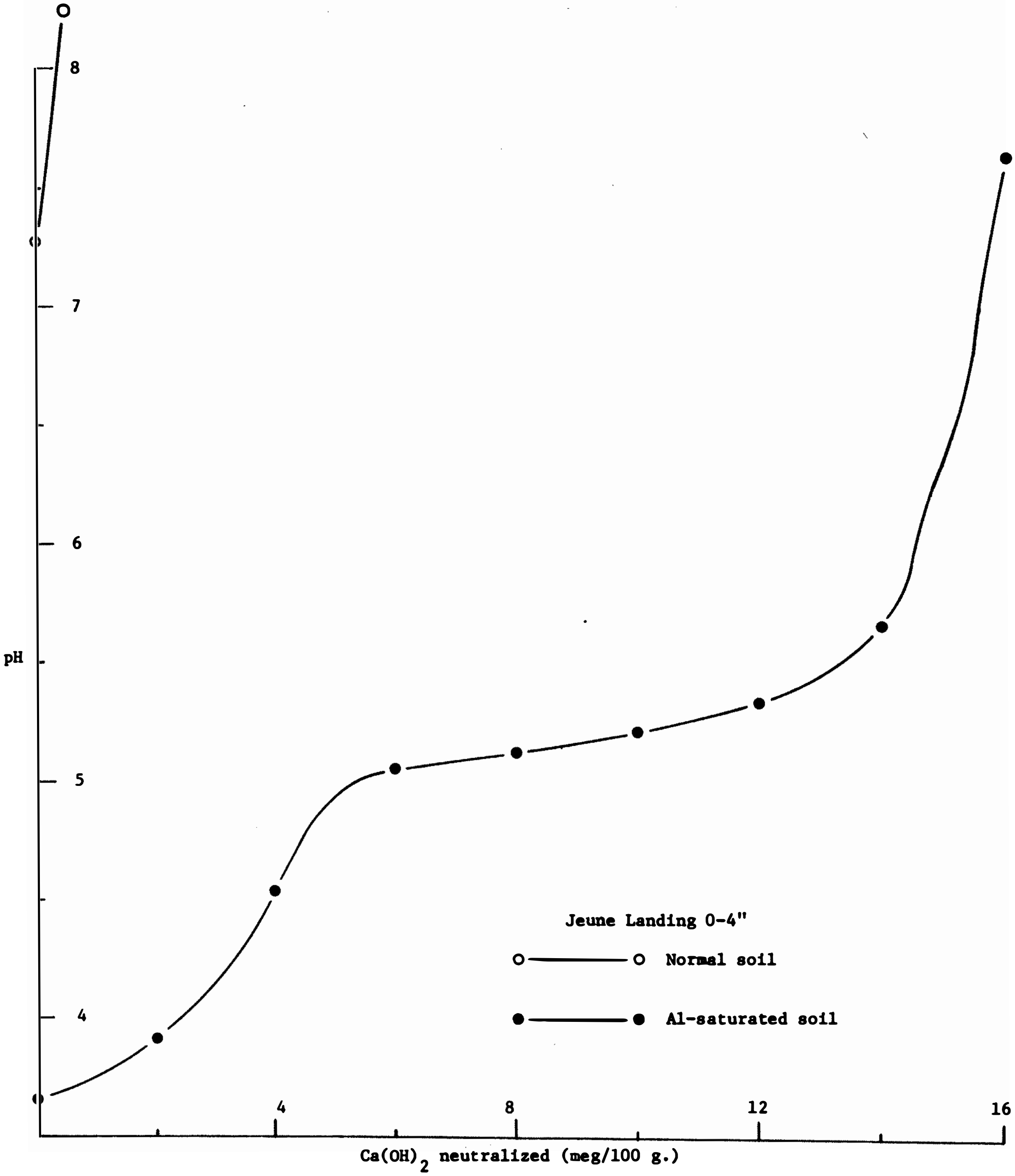

Figure 5 - Continued/Jeune Landing 0-4"

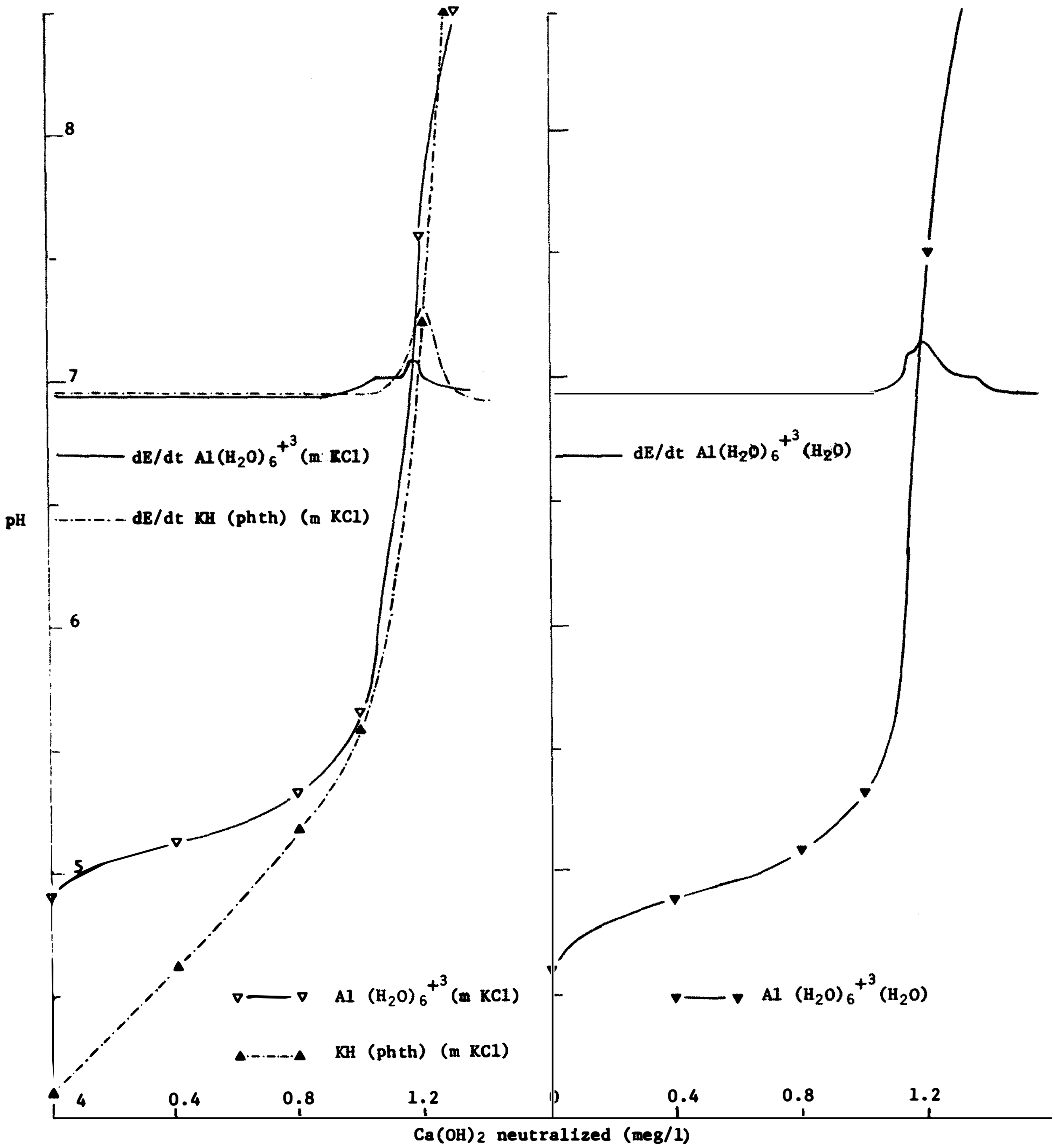

Figure 6 - Hydrolysis of Al $(H_2O)_6^{+3}$ ion in molar KCl and H_2O and neutralization of KH phthalate; (both the normal and first derivative (dE/dt titration curves are shown)

TABLE 1. ACIDITY AND EXCHANGE CHARACTERISTICS OF THREE VANCOUVER ISLAND SOILS.

Sample	Depth inches	pH[1]		Soil Acidity				Ext. Bases	C.E.C.
		Initial	End-point	Extract	Leached Soil	Unleached Soil	Created by neutralization		
						meg/100g.			
P.R.	4-0	3.92	5.50	14.50	5.30	24.80	5.00	20.9	36.0
	0-4	4.51	5.50	4.78	0.30	5.40	0.32	3.9	6.8
W.C.	4-0	3.46	5.40	25.00	16.00	51.20	10.20	24.7	48.4
	0-4	4.22	5.40	10.50	0.90	12.80	1.40	4.6	16.9
J.L.	4-0	4.66	5.40	1.10	0.40	2.48	0.98	37.5	32.7
	0-4	7.24	5.40	0.50[2]	3.08[2]	3.44[2]	-	79.3	13.4

[1] The endpoint values are those of the KCl-extracts but were used to evaluate the acidity in the leached and the unleached samples.

[2] The surface mineral soil of Jeune Landing (0-4") required the addition of standard acid to reduce the initial pH value to 5.40.

TABLE 2. ACIDITY OF MINERAL SOILS LEACHED SUCCESSIVELY WITH NEUTRAL UNBUFFERED SALT AND 10 PER CENT ALUMINUM SOLUTIONS

Soil	Depth inches	pH		Acidity in Extract		Exchangeable Bases				C.E.C.[2]
		Initial[1]	End-point	Normal Soil	Al-saturated Soil	Ca	Mg	K	Fe	
					meg/100 g.					
P.R.	0-4	4.63, 3.75	5.5	4.80	8.56	0.71	0.80	1.47	0.97	8.56
W.C.	0-4	4.10, 3.54	5.4	10.80	16.20	1.54	0.60	1.36	1.08	16.20
J.L.	0-4	7.26, 3.65	5.4	nil	12.70	75.80	1.68	1.36	0.60	12.70

[1] The two initial pH values recorded for each soil are for normal and Al-saturated samples.

[2] Here, the C.E.C. is taken to be "effective exchange capacity" and is equal to the acidity in the salt extracts from the Al-saturated samples (actually the extract-acidity of the Al-saturated samples approximates the extract-acidity of the normal soil plus the exchangeable cations or bases in samples not excessively based-saturated, i.e., J.L. 0-4")

TABLE 3. REDUCTION (%) IN SALT-EXTRACTABLE AND TITRATABLE SOIL ACIDITY BY THE ADDITION OF UREA-NITROGEN.

Sample	Depth inches	Per Cent Reduction in Soil Acidity			
		Salt-extractable		Titratable	
		400#N	800#N	400#N	800#N
Port Renfrew	4-0	21.0	46.0	4.0	5.0
	0-4	39.0	60.0	37.0	42.0
Woss Camp	4-0	53.0	64.0	0.0	0.0
	0-4	20.0	40.0	0.0	0.0
Jeune Landing	4-0	46.0	73.0	26.0	55.0
	0-4	-	-	-	-

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