

Method for water extractable phosphorous in saline-sodic soils

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Abstract

Soil phosphorous dynamics in saline-sodic soils is not well understood and lack of applicable methods for saline-sodic soils is a major problem. One method used for soluble-P measurements in saline-sodic soils includes using anion exchange resins. Water addition to dry saline-sodic soils may cause reactions and fluxes in the pH which can result in inaccurate measures of soluble-P. A low-molar salt solution can be used to stabilise the pH for extraction. Six mixes of a saline-sodic soil were extracted with a low-molar salt solution and compared with the standard deionised water extraction using the anion exchange resin method. Two further extracts were undertaken on all the soils, following the Hedley procedure. The first fraction of P was shown to be significantly less ($p > 0.005$) with a salt extraction, compared to water extraction. Subsequent P was not recovered in the second and third extraction. Further research is being undertaken on the recovery rates of soluble-P with low-molar salt extractants; through recovery rates, full-fractionation of different saline-sodic soils; and determining correction factors.

Key Words

Phosphorous; saline; sodic; nutrients; methods

Introduction

Water soluble-P and P dynamics in saline-sodic soils has undergone limited research. Curtin and Naidu (1998) suggest that this is largely due to the lack of methods suitable for saline-sodic soils. Exchangeable sodium and pH influence solubility of P in soils (Curtin and Naidu 1998; Gupta and Abrol 1990; Naidu and Rengasamy 1995). Thus, sodic soils have inherently high rates of available P. Saline-sodic soils with high pH (>8.0) may also contain Ca-P complexes. Common P-extraction techniques, such as Colwell (1963) and Olsen *et al.* (1954), use extractants which may extract Ca-P complexes or contain Na which may overestimate soluble-P (Curtin and Naidu 1998). Colwell and Olsen methods are not advisable for P analysis when considering plant available sources due to over or under estimation of different P-fractions (Curtin and Naidu 1998). Suggested methods to deal with these problems include ion-exchange membranes (Curtin and Naidu 1998), ammonium fluoride (Bray and Kurtz 1945; Hazelton and Murphy 2007) and NH_4HCO_3 with DTPA (diethylenetriamine penta-acetic acid) (Chun *et al.* 2007). These methods use water or other non-cation extractants. This limits chemical interference with Ca-P complexes or changes in solubility of P. Subsequent fractionation of P using the Hedley method (Hedley and Stewart 1982) can be undertaken to determine levels of P in other forms. An appropriate fertiliser or organic amendment regime can then be determined.

Water extraction of P in saline-sodic soils also has limitations. The addition of water to a saline-sodic soil after drying can cause a chain of reactions due to the high surface potential of the soil (Curtin and Naidu 1998; Thomas 1996). Depending on the amount of exchangeable Na, Ca, other cations and the presence of carbonates, the pH of the solution can increase or decrease with water addition (Curtin and Naidu 1998; Thomas 1996). Therefore, the fractions of P may be altered from the time it was sampled. A low-molar salt solution has been used in some P-extraction techniques (Lajtha *et al.* 1999) to limit variability of changing salt concentrations (Thomas 1996). Low molar salt solutions have not previously been used in the anion exchange resin method as a method of stabilising the pH over the 18 hours of extraction. This paper will demonstrate the efficacy of the extraction of water soluble-P in dried saline-sodic soils using a low-molarity salt solution compared to deionised water. It will examine whether there is a loss of P as a result of water extraction by undertaking two subsequent extractions using the Hedley fractionation method (Hedley and Stewart 1982; Lajtha *et al.* 1999). The potential for a low-molarity salt solution to buffer pH change in the extraction of water soluble-P in saline-sodic soils is included.

Methods

Saline-sodic regolith from the Cowal Gold Mine, characterised as a mix of lake-bed sediments and cracking clays, with some oxide and waste materials were used. The pH (1:5 H₂O) ranged between 7.55 and 8.84; EC ranged between 1.3-1.6 dS/m and the ESP was 28. The soils had been previously ameliorated for 12 weeks under a 2 x 3 factorial experiment (with or without gypsum, no compost / compost or fresh woodmulch). Soils were divided into 6 mixes, depending on treatments they had received (Table 1). Approximately 0.25g of each soil mix was measured out 8 times for each of the two exchange methods. Four reps from each sample were then used as replicates for each of the extractants. In half of the soils, 30mL of deionised water was added, the other half received 30mL of 0.05M KCl solution. Anion exchange membranes were added to each tube and left on rotation for 18hrs. Membranes were extracted at 18hrs and placed into a weighed volume of approximately 25mL of 0.5M HCl. P was extracted from the membranes by rotation for another two hours. Soil was kept for two more extractions using NaHCO₃ and NaOH in the Hedley method (Hedley and Stewart 1982; Lajtha *et al.* 1999). The malachite green procedure was then used to analyse P in each of the extracts (Lajtha *et al.* 1999), using a Varian Cary 50 at 630nm absorbancy.

Table 1: Soil Classes and treatments undertaken over a 12 week period

Soil Mix	Contents
1	Soil
2	Soil + Compost
3	Soil + Woodmulch
4	Soil + Gypsum
5	Soil + Gypsum + Compost
6	Soil + Gypsum + Woodmulch

Results

P extracted using KCl was lower compared to water extraction, with an average difference of between 0.52 and 37.86ppm. In soils with compost added (mix 2 and 5), the difference between the two extracts was highest, with averages of 25.11 and 37.86ppm lower with KCl extract (Figure 1). The average standard deviation between the replicates for water or KCl was 2.31 and 1.24 respectively. The correlation coefficient of the two data sets is 0.4034, and data sets were significantly different $p > 0.005$. The difference between the DI water and KCl on second (NaHCO₃) and third (NaOH) extracts was reverse, with KCl averaging between 0.12 and 9.40ppm more P present (Table 2). An exception for NaOH extracts occurred in soils 5 and 6, which had less P in the KCl extracted soils. The average recovery of P in the later fractions was only 8.2-74.2% of the difference between the first extracts. The total of all three extracts have an average difference between 1.2 and 24.5ppm for the soils originally extracted with KCl. Total recovery of P in soils extracted with KCl was between 79.2 and 95.7% of total P in soils extracted with DI water, with the two lowest averages being the soils treated with compost (2 and 5). Correlation of the extract-totals is strong, with a factor > 1.0 .

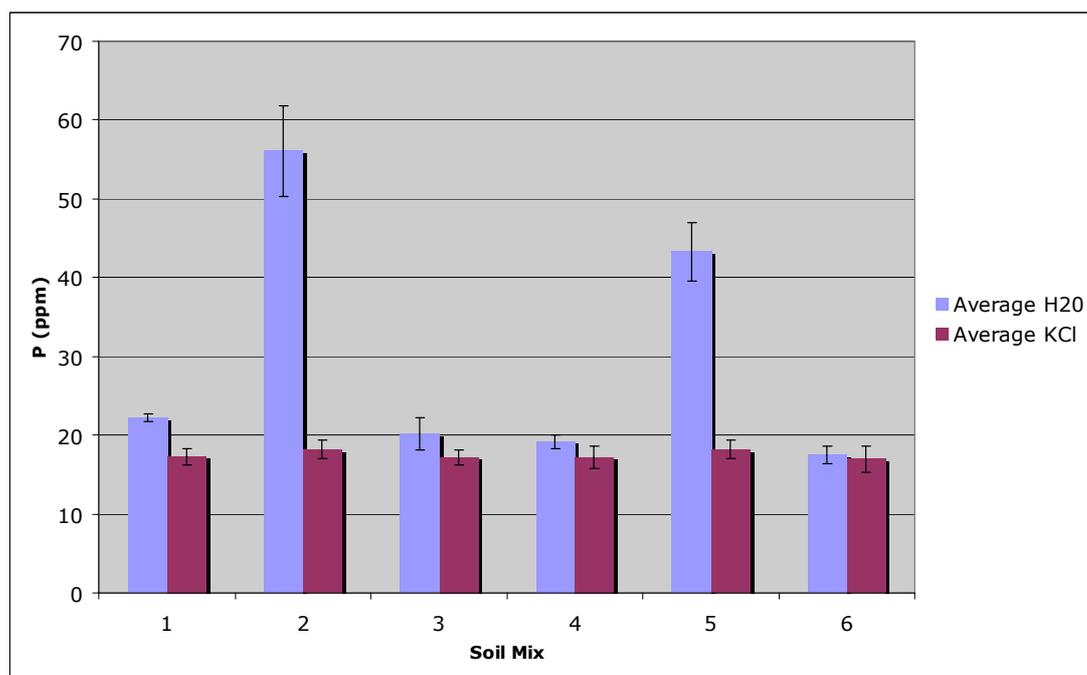


Figure 1. Average P-extracted (ppm) for DI Water and KCl extracts with error bars (standard deviation).

Table 2. Average soil P from replicates of the three extracts

Soil Mix	First Extract		2 nd Extract		3 rd Extract		Total of 3 Extracts	
	Water (ppm)	KCL (ppm)	Water (ppm)	KCL (ppm)	Water (ppm)	KCL (ppm)	Water – KCl (ppm)	KCl as % of Water
1	22.27	17.27	7.09	7.42	5.39	5.51	4.54	86.94
2	56.06	18.20	66.98	76.38	20.73	24.65	24.54	82.93
3	20.24	17.12	6.35	7.01	5.07	6.02	5.12	83.82
4	19.18	17.16	6.73	7.30	4.58	4.76	1.28	95.79
5	43.30	18.19	50.48	53.70	17.03	15.88	23.05	79.20
6	17.51	16.98	6.35	7.03	4.61	4.30	3.22	89.79

Discussion

There was a reduced amount of extracted soluble-P with a low-molar salt solution compared to DI water. Subsequent extractions from soil extracted with salt-solution had increased levels of P, but not sufficient to be equal to the different amount in the initial extraction. It is possible the salt-solution caused a decrease in pH (Thomas 1996). This would have locked the P into other fractions that were not recovered in the scope of this experiment. Furthermore, DI water may have made P more available in the first extract compared to later fractions due to an increase in pH (Thomas 1996). Full fractionation of total P using the Hedley procedure is required to understand the dynamics of P with KCl and water extracts. The pH should also be measured hourly to understand any reactions occurring in the solutions that may affect pH and consequent P solubility and dynamics. The KCl may have also had interference with the ion-exchange membrane. Chloride may have taken up some of the positions on the membranes, making them less available to P ions. This problem may be reduced by using more membranes. A different salt solution may also be used in place of KCl. A lower molar salt-solution (0.01 or less) should also be tested to determine if it recovers a greater level of soil P. Correction factors are used to deal with change in partial pressure when measuring pH in 0.01M CaCl₂ (Thomas 1996). Therefore, a correction factor may be necessary when extracting with a

salt solution. Compost added to a soil was shown to have the strongest rate of non-recovery compared to the other soil treatments. Additions to soil should be thoroughly analysed for full P-fractionation, eH, pH and EC to determine any interactions that may have occurred in the soil system, including those of P dynamics. Further investigation of the recovery of P with low-molar salt solutions is being undertaken. Both recovery of P and other saline-sodic and non-saline-sodic soils are being investigated. It is anticipated that full fractionation and P-sorption capacity will highlight any changes in P fractions with low-molar or water extractions.

Conclusion

Phosphorous dynamics in saline-sodic soils is not well understood. Current methods utilise soil fractionation, and water extractable P as the first fraction. Water extracts can cause changes in soil chemistry, which may influence the recovery of P in different fractions. Salt-solutions in place of water may limit changes in P fractions. A low-molar salt solution was compared with water as a first fraction extractant. The recovery of P was lower in salt-solution compared to water, and was not recovered after a further two extracts. This may have been due to changes in pH caused by the salt-solution, water, interference on anion exchange membranes, molarity of salt solutions, need for correction factors and lack of understanding regarding P fractionation. Further research is being undertaken to determine the recovery rate of soluble-P with low-molar salt solutions, including a wide range of saline-sodic, sodic and other soils. Full fractionation and sorption capacity of the soils is expected to demonstrate whether salt-solutions or water change soil P fractions. A correction factor will be formulated if required. Data will also be used to further understand soil P dynamics in saline-sodic soils.

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