WHAT DO HIGH OLSEN P VALUES MEAN ON PUMICE-GRAVEL SOILS IN THE ROTORUA DISTRICT?

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Abstract

To achieve maximum pasture production on pumice soils, Olsen P levels of 35-45 mg/L are required. However, Tarawera and Matahina gravel soils (subgroups of Pumice soils) have been found to require Olsen P level of approximately 90 mg/L to maintain maximum pasture production.

Forty-one sites from the Bay of Plenty region were sampled to a depth of 75 mm. The soils included Tarawera gravel (11), Matahina gravel (10), Rotomahana mud (7), Oropi sand (4), Taupo ash (7) and Kaharoa ash (2).

The amount of material that did not pass through a 2 mm sieve (gravel) ranged from 24-67% and 9-29% for the Tarawera and Matahina gravel soils respectively. For the other soils there were minimal amounts that did not pass through a 2 mm sieve. Olsen P, P retention, total P, 0.01 M $CaCl_2$ extractable P (potential P-leaching) and total Cd were measured on the <2 mm fraction, gravel only fraction and a mixture of the two fractions which was naturally found in the field.

This study showed that the exclusion of the gravel fraction prior to analysis (common laboratory practice) would have lead to the higher Olsen P values required to maintain maximum pasture production when pasture growth trials were conducted. The exclusion of gravel will also have implications on other chemical tests such as Cd levels in the soil.

Most of the sites within this study had low to medium phosphate retention (11-52 %) and elevated Olsen P values (average value 57 mg/kg). Sixty-seven percent of the sites within this study had levels of 0.01 M $CaCl_2$ extractable P > 0.15 mg/L.

Introduction

In 1886 the Mt Tarawera eruption scattered basaltic lapilli (Cottier and Hewitt, 1925) and ash over the surrounding landscape. Basaltic lapilli are basalt type rock with size varying between 2-64 mm (lapilli). The major elements found in basalt consist of sulphur, aluminum, iron and magnesium making 47-48% of the content. Phosphorous in basalt has been reported to be at 900 and 6400 mg/kg depending on the type of basalt (*Pers.comm*. Dr. Adrian Pittari,Waikato University, Earth & Ocean Sciences).

The land at the time of the eruption was dense forests and scrubland (Nicholls, 2006). Since then much of the land has been converted to pastures. Bay of Plenty Regional Council state that 43.9% of the land is used commercially; 23.8% pastures and 20.1% forestry (Bay of Plenty Regional Council Website).

Studies found that to get maximum pasture yields a level of approximately 90 mg/L of Olsen P in Tawarewa gravel soils was required (Hawke and O'Connor, 1998). However, for pumice soils usually Olsen P concentrations of 35-45 mg/L are required to attain maximum pasture production (Roberts and Morton, 2009). Standard preparation of samples at the laboratory removes gravel to produce a fraction of soil that passes though a 2 mm sieve. The removal of gravel prior to analysis would not be representative of what is found in the field.

The aims of this study was to show that the removal of gravel would have caused the apparent high Olsen P levels required for maximum pasture production when field trials were carried out. Also the potential of P to be lost via subsurface flow (leaching) was assessed for these soils.

Method

Sampling - Forty-one sites were sampled around the Rotorua district. The samples were split into three fractions and compared against other soils from the same region that contained insignificant levels of gravel. Most of the Bay of Plenty region is comprised of Pumice or Recent soils. Figure 1 shows the different soil types in the Bay of Plenty and also indicates sampling locations that were used for this study. Soil types used for this investigation include Tarawera gravel, Matahina gravel, Rotomahana mud, Oropi sands, Kaharoa ash and Taupo sandy silt. Soils were sampled to a depth of 75 mm around the Rotorua area during November/December 2010.

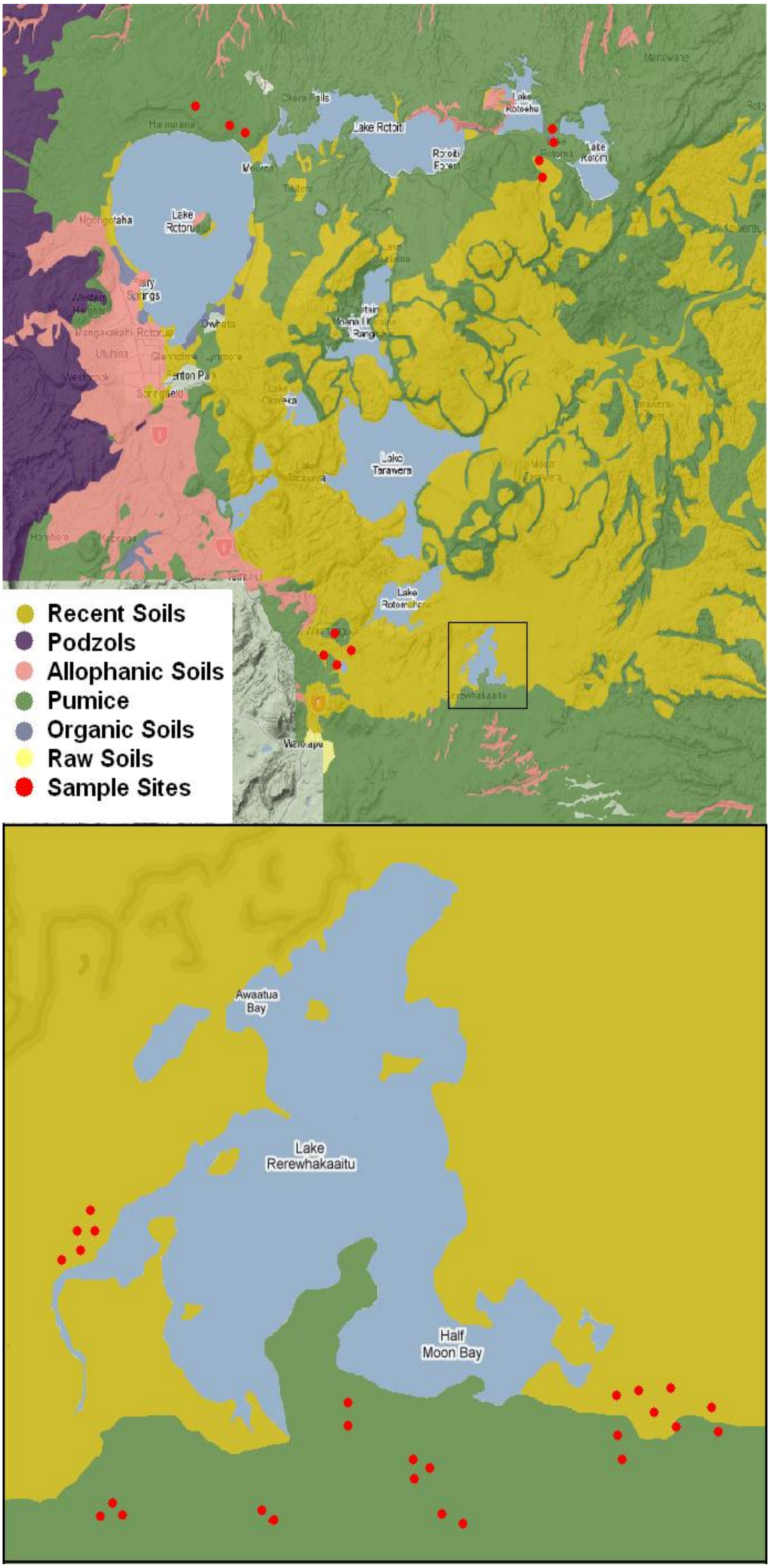
Soil Fractions - Samples were split into soil fractions of **<2 mm** and **Gravel** by passing through a 2 mm sieve. The two fractions were weighed separately to find the ratio of gravel to soil. From the known ratio a mixture of the two fractions were composited on a weight basis to make a **Field Representative** fraction. The gravel fractions were initially washed with tap water, and then washed three times with distilled water to remove any fine soil particles.

Chemical Tests - Olsen P was measured using the MAF, Soil Fertility Service Lab method to determine the levels of plant available phosphate in New Zealand soils. The method employs a $NaHCO_3$ extraction method developed by Olsen *et al*. (1954), where the phosphate concentration in the extract is determined by a phospho-molybdate method proposed by Watanabe and Olsen (1965) and Murphy and Riley (1962). Olsen P is determined on a volume basis where a 5 mL of soil, (using a calibrated scoop), is extracted with 100 mL of 0.5 M $NaHCO_3$ and reported as mg/L.

Phosphate retention (PR) or Anion Storage Capacity (ASC) is determined by shaking the soil with a buffered phosphate solution for 16 hours. The amount of phosphate remaining in solution was determined colorimetrically at 420 nm (Blakemore *et al.*, 1980).

Calcium chloride (0.01 M) extractable P was measured by adding 4 g of the field representative soil sample to 20 ml of solution and shaking for 30 minutes. The 0.01 M $CaCl_2$ extractable P gives an indication of the amount of dissolved reactive P (DRP), which potentially may be lost via subsurface flow (Hedley *et al.,* 2002; McDowell and Condron, 1999).

Figure 1: The different soil types found in the Bay of Plenty and locations sampled.



Results and Discussion

Table 1 gives a summary of the range of results for tests conducted on the samples for each soil type and their fractions. The amount of gravel that did not pass through a 2 mm sieve ranged from 24-67% and 9-29% for the Tarawera and Matahina gravel soils, respectively. The other soil types did not contain gravel.

Table 1: Summary of the range of results for all tests conducted on the samples for each soil type and their fractions.

Soil Type	**Olsen P** (mg/L)	**Gravel** (%)	**PR** (%)	**Total Cd** (mg/kg)	**Total P** (mg/kg)
Matahina (< 2 mm)	65-113	-	20-35	0.30-0.68	982-1785
Matahina (field represenative)	44-82	-	10-47	0.28-0.64	869-1627
Matahina (gravel)	16-54	9-29	4-16	0.05-0.54	66-560
Tarawera (< 2 mm)	49-122	-	10-29	0.28-1.44	781-3330
Tarawera (field represenative)	38-71	-	11-21	0.32-1.13	889-2500
Tarawera (gravel)	11-36	23-67	3-5	0.06-0.21	315-625
Rotomahana mud	17-71	-	22-34	0.39-0.71	805-1744
Taupo sandy silts	29-90	-	36-52	0.41-0.74	914-1918
Oropi sands	41-88	-	26-52	0.36-0.49	1031-2150

– : not applicable

The relationship in Olsen P values for different soil fractions for the Tarawera and Matahina soil types is given in Figure 2. Samples that were field representative produced results between the <2 mm fractions and the gravel only fraction. Interestingly there was P extracted by $NaHCO_3$ from the gravel only samples.

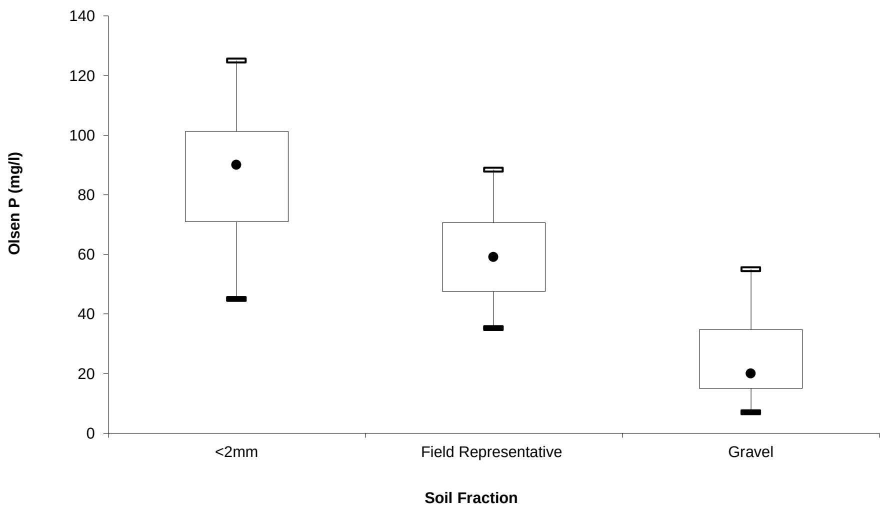


Figure 2: Relationship in Olsen P values for different soil fractions for the Tarawera and Matahina soil types. Dots represent the median.

Olsen P ranges for different soil types for the **<2 mm fractions** are shown in Figure 3 while the Olsen P ranges for different soil types for the **field representative fractions** are shown in Figure 4. There was a significant decrease ($p < 0.05$) in Olsen P values for the Matahina and Tarawera gravel soils with the inclusion of gravel (the field representative fraction) .

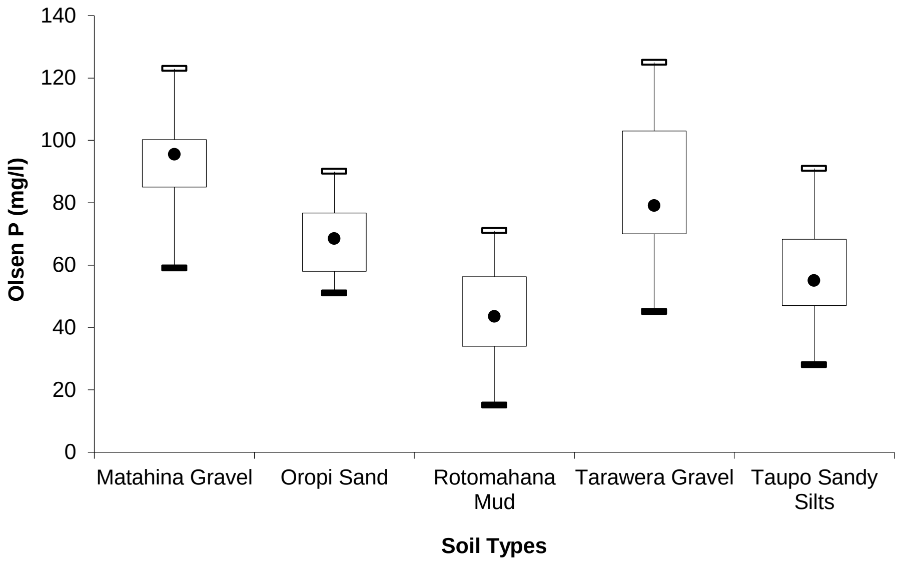


Figure 3: Comparison in Olsen P ranges for different soil types for the **<2 mm fraction**. Dots represent the median.

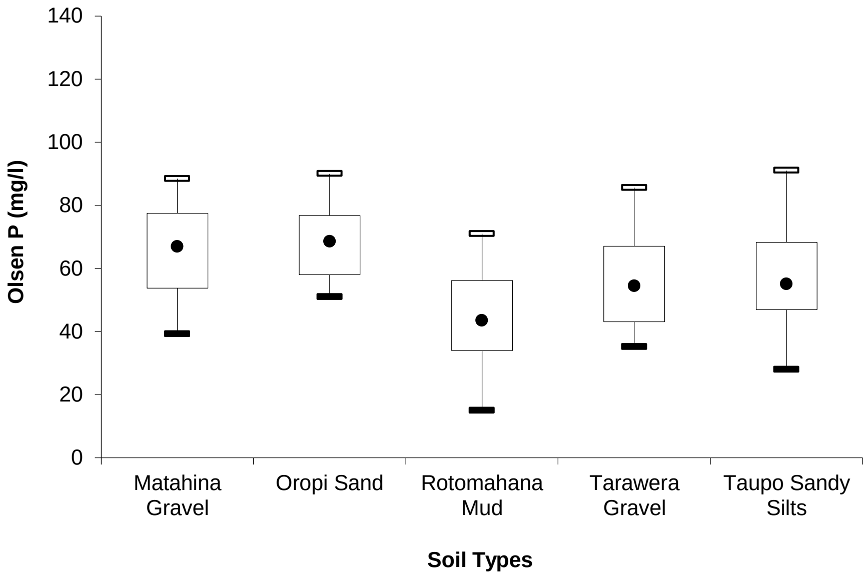


Figure 4: Comparison in Olsen P ranges for different soil types for **field representative fractions**. Dots represent the median.

The average decrease in Olsen P with the inclusion of gravel (field representative fraction) was 30.3%. The Olsen P for Matahina gravel soils decreased with an average of 27.9% and for Tarawera gravel soils the average decrease was 32.9%. The relationship between decrease in Olsen P and the amount of gravel in a field representative sample is not a linear relationship and is presented in Figure 5. The deviation from linearity is due to an equilibrium existing between Olsen-P in the fraction measured and the solution (Rajendram et al., 2003; Barrow and Shaw, 1976).

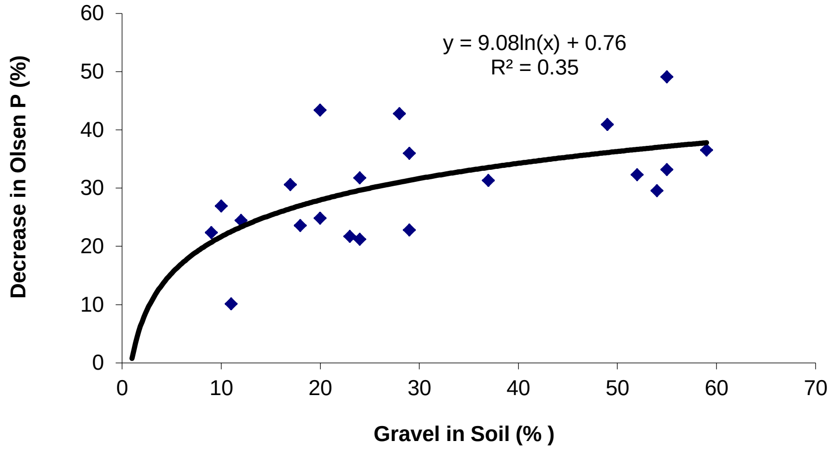


Figure 5: Relationship between percent decrease in Olsen P and amount of gravel in soil.

There was a linear relationship between total Cd and total P levels in the sample fractions analysed (Figure 6). When total P concentrations were approximately 2300 mg/kg, Cd concentrations in the samples reached 1 mg/kg.

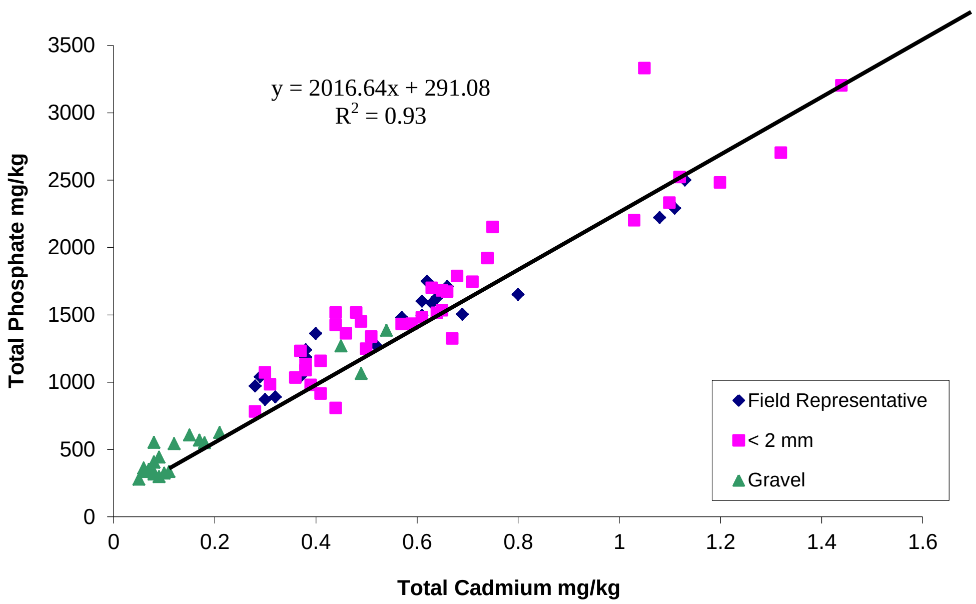


Figure 6: Relationship between total Cd and total P for all fractions in the study.

Most of the sites within this study had low to medium phosphate retention (11-52 %) and elevated Olsen P values (average value 57 mg/kg) for the **field representative fraction**. The Tarawera and Matahina gravel soils had low P retention, which resulted in elevated 0.01 M $CaCl_2$ extractable P (Figure 7). The 0.01 M $CaCl_2$ extractable P gives an indication of the amount of dissolved reactive P (DRP) that potentially may be lost via subsurface flow (Hedley *et al.*, 2002; McDowell and Condron, 1999). Sixty-seven percent of the sites within this study had levels of 0.01 M $CaCl_2$ extractable P > 0.15 mg/L. The threshold of 0.15 mg/L of P was used in this study as in Hedley *et al.*, (2002). The dotted line on the graph represents 0.15 mg/L of extractable phosphate. This finding confirms previous work (Ghani *et al.*, 2005), where elevated levels of P were found in 1 M depths for Tarawera gravel soils.

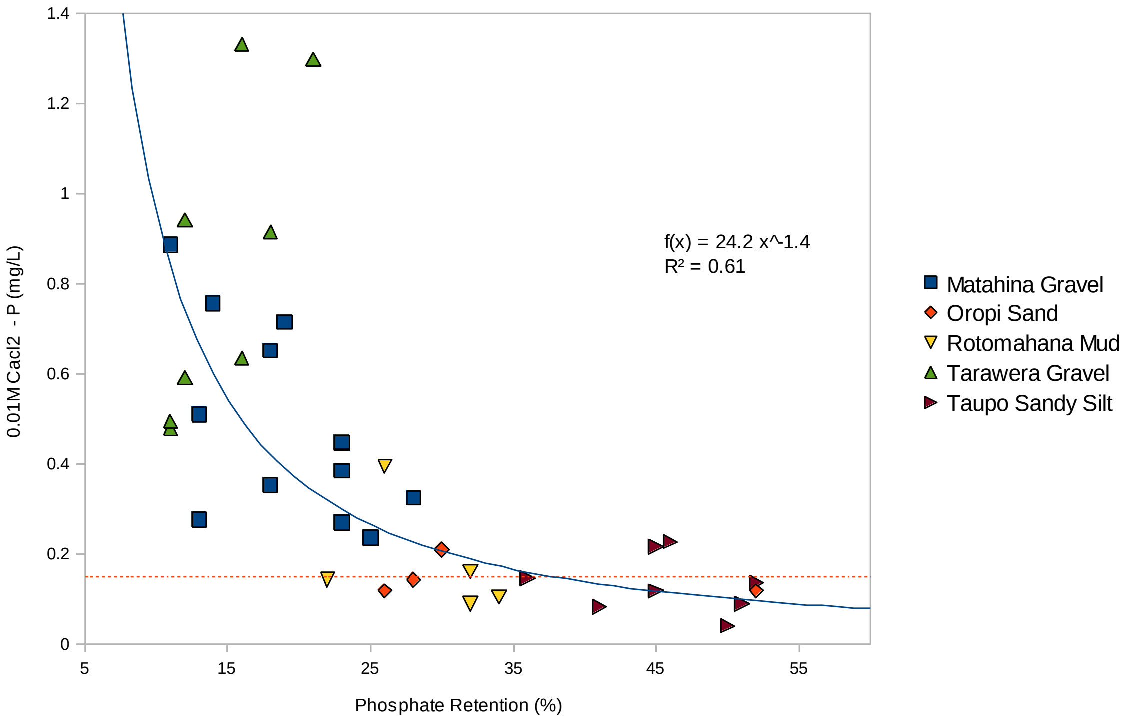


Figure 7: Relationship between 0.01 M $CaCl_2$ extractable P and phosphate retention on field representative fractions. The dotted line represents 0.15 mg/L of extractable phosphate.

Conclusion

This study showed that the exclusion of the gravel fraction prior to analysis (common laboratory practice) would have lead to higher Olsen P values required to maintain maximum pasture production.. Testing the soils with gravel will become more representative of the original sampled soil, particularly if the soils contain large amounts of gravel.

The Olsen P concentration for Tarawera and Matahina gravel soils decreased when gravel is included in the testing procedure and a better agreement to the advised range in Olsen P (35-45 mg/L) for Pumice soils was seen.

The exclusion of gravel will also have implications on other chemical tests such as total Cd levels in the soil.

Phosphorus (P) loss from soil due to leaching or overland flow is implicated in eutrophication of surface waters. The soils used in this study, which had low PR, and high Olsen P had elevated $CaCl_2$ extractable P, which could lead to P loss via sub-surface drainage.

Future testing for soils should be conducted on a field representative sample. It is recommended that laboratories should include gravel in the fraction measured particularly in high gravel soils.

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