Prediction of runoff P concentration on diverse soils using routine soil P tests

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Concentrations of phosphorus (P) in runoff from intensively managed dairy pastures are often high, but are highly variable between soils for a given soil test P value. Although measures of soil P such as weak electrolyte extractable P and P saturation provide better predictors of runoff P concentration, they are not routinely measured in Australian soils. The development of reliable prediction of potential runoff P concentration using routine soil tests would benefit risk assessment and water quality modeling efforts alike. Partitioning of P between the solid and solution phases is controlled by P quantity and buffering properties of the soils. In this research, we investigated the effect of two agronomic bicarbonate extractable soil P tests (Olsen P and Colwell P), and P buffering (PBI) on runoff P concentrations using rainfall simulation. Non-routine soil tests such as $CaCl_2$ extractable P and P sorption saturation were also examined. Six soils were collected that had a wide range of soil PBI (~20–1200). Fifteen runoff trays for each soil were packed with soil that had varying amounts of P added in order to achieve a wide range of soil test P (STP) values. The trays were incubated for 8 months, during which pasture was grown and then artificial rainfall was applied. Runoff was collected and analyzed for dissolved and total P (TDP and TP respectively). Soil samples (0–0.01 m) were collected and analyzed for the soil P parameters previously mentioned. Relationships between soil test P and runoff P were then examined.

Soils with low PBI had much higher concentrations of P in runoff than soils with high PBI, for given Olsen and Colwell P values. For example, soils with low PBI's and STP values three times the agronomic optimum (common levels on Australian dairying soils) resulted in P runoff concentrations in the range of 5-8 mg/L. In contrast, soils with the same STP excesses, but high PBI's had P runoff concentrations of <1 mg/L. The relationship between both Olsen P and Colwell P and runoff P (TP and DRP) was significant ($P<0.01$) for each soil. However both agronomic soil tests were found to be extremely poor predictors of runoff P concentration across all soils. This limits their use in modeling and risk analysis. A model including the terms Colwell P or Olsen P and PBI was found to explain >80% of the variation in runoff TP and DRP concentrations. Although $CaCl_2$-P and P saturation are equally effective predictors of runoff P they are not routinely measured in Australian laboratories, thus limiting their utility. From an environmental management perspective, particular attention should be paid to management of P fertility and runoff P risk on soils with low P buffering.