Potential soil P transfer to runoff water in areas fertilized with organic residues

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Objectives
1- Evaluate P losses from soils fertilized with organic residues and with commercial fertilizers by: A - runoff waters and B - laboratory desorption experiments.
2- Evaluate the relationship between soil P tests and P losses to runoff waters.
3- Compare the results of P losses obtained by field experiment and by laboratory desorption experiments.

Materials and Methods
1- The field experiment, was performed in a Dystric Regosol with 9% slope; This area has 18 plots each with 42 m² equipped with a runoff water collection box. The experimental design consists of 6 treatments according with fertilizer P origin with three repetitions per treatment. The amount of P added to soil was 50 kg P ha⁻¹. Treatments were: control, no P added (C); mineral fertilization (F); cattle manure (M); dry fraction of pig effluent (P); dry fraction of duck effluent (D); dry fraction of pig effluent on bare soil (BP).
2- Ryegrass was sown in November 2012 one month after P fertilization.
3- Runoff water was collected when precipitation events originates runoff.
4- A P desorption experiment to a dilute electrolyte (0.002 M CaCl₂) in the laboratory was carried out. Fertilized soil samples of each plot were incubated during 90 days at 24°C. A soil:solution ratio 1:1000 was used to mimic runoff conditions and the dissolved reactive orthophosphate (Pd) in the supernatant after centrifugation (13 000 rpm) was determined.
5- Ammonium lactate-P (Al-P) and Olsen P were determined in the soil every 3 months.

Results

- Pd in runoff water samples showed no significant differences between treatments. The average value of Pd in all treatments (including C) was > 0.15 mg L⁻¹
- A high variability in the volume of runoff water was observed (CV from 82% in C to 170% in D treatments), which can be partly attributed to differences in solum depth and preferential flow pathways.
- In the laboratory desorption experiment, all P-fertilized samples had significantly higher (p <0.001) Pd levels than control samples. The D treatment resulted in significant higher levels of Pd (0.50 mg L⁻¹) than the P, BP, F (0.05 - 0.1 mg L⁻¹) or M (0.03 mg L⁻¹), with no significant differences between the latter.
- After three months Olsen P increased significantly from 10 ± 3 mg kg⁻¹ (at the beginning of the experiment) to 34 ± 18 mg kg⁻¹ with the addition of fertilizers. Considering the effect of fertilizers the D treatment resulted in significant higher (p <0.001) soil P levels while there were no significant differences between P, BP, M or F. The large difference between P-AL and Olsen P in the D treatment suggests the presence of P forms more soluble in acid extractants.

Conclusions
1- P losses from soil to runoff waters
   - Field experiment
     P fertilization with organic residues or commercial fertilizers originates levels of Pd in runoff waters always higher than 0.05 mg P L⁻¹ the critical level to prevent eutrophication of water bodies.
     No significant differences of Pd in runoff water were observed between treatments even between fertilized and the control plots.
   - Laboratory desorption experiment
     D treatment shows significant higher potential to desorb P from soil to runoff water than the other organic residues or the commercial fertilizer. Phosphorus fertilization increases significantly P losses to water.

2- Relationship between soil P tests and P losses to runoff waters
   Results of soil P tests and of Pd in the desorption experiment are significantly correlated (R= 0.99) but are not with Pd in runoff waters.

3- Compare P losses evaluated by two different procedures
   No correlation between the Pd values found in the desorption experiment and the corresponding ones in runoff water was found.
   Both P sources and soil profile features play an important role in soil P transfer to runoff waters, which is difficult to assess by laboratory experiments.