Slurry amendments reduce incidental P losses – but what about N and GHG losses?

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Introduction

Land application of dairy and pig slurry can result in phosphorus (P) and suspended sediment (SS) losses to runoff along a transport continuum. There is a need to identify new P mitigation measures if the EU Water Framework Directive water quality targets are to be met beyond 2015. Research in this field must also take cognisance of gaseous emissions and nitrogen (N) losses in leaching and runoff pathways. Mitigation measures are synergistic and therefore must be examined in a holistic manner to prevent pollution swapping. This paper presents the results of a four-step iterative laboratory and field-scale approach that ranks proven P sequestration amendments from best to worst based on these other potential loss pathways.

Methods

Step 1: Uses an Agitator test, which takes an intact soil core from the field. This is then placed in a beaker, and treatments (control soil, slurry only and amended slurry) are applied to the soil surface. The soil is then overlain by 500 ml of deionised water before a paddle is inserted and rotated to simulate overland flow. This enables effectiveness and optimal application rates to be determined. Step 2: Uses a simulated rainfall and runoff box, comprising a 1 m-long intact soil section, which is subjected to simulated rainfall with an intensity of 10 mm hr^{-1}. Runoff water is sampled for nutrients, SS and metals at regular intervals. Step 3: Uses micro-plots in the field under real drainage conditions. Step 4: Uses laboratory column and incubation experiments to quantify nutrient leaching and the effect of treatments on greenhouse gas (GHG) emissions.

Results

Alum, ferric chloride ($FeCl_2$) and poly-aluminium chloride (PAC) all had >70% effectiveness at controlling total P and SS losses, but varied in their ranking with respect to other criterion. For pig slurry, agitator results showed that soluble P removal criteria of 70% was achievable using stoichiometric rates of 0.88:1 Al: P, 0.89:1 Fe: P and 0.72:1 Al: for alum, $FeCl_2$ and PAC, respectively. The laboratory flume showed that PAC performed best (alum was worst) at DRP, DUP, TDP, TP, PP and SS removal. However, column experiments showed that $FeCl_3$ had the highest cumulative losses of 1880±864 g nitrous oxide (N_2O)-N ha^{-1}, where alum and PAC did not significantly differ from the unamended slurry treatment and were not significantly different from each other. For pig slurry, the amendments were ranked from best to worst: PAC, alum, and $FeCl_2$. For dairy slurry, the agitator experiment showed that soluble P removal criteria of 70% was achievable using the rates of 1.11:1 Al: P, 2:1 Fe: P and 0.93:1 Al for alum, $FeCl_2$ and PAC, respectively. The laboratory flume showed that PAC performed best ($FeCl_2$ worst) at DRP, DUP, TDP, TP, PP and SS removal. The field plot results validated these results [1]; however, alum increased incidental N losses compared to slurry. A laboratory gas chamber experiment showed that amendments did not increase global warming potential of slurry, but pollution swapping can occur. Based on P removal effectiveness and pollution swapping for dairy slurry, the amendments were ranked from best to worst: alum, PAC, and $FeCl_2$.

Conclusions

Most slurry amendments are effective at controlling incidental P losses, but results show that different amendments may cause problems with respect to N and GHG losses. Holistic ranking of alum, PAC and $FeCL_2$ amendments showed that the efficacy differed for dairy and pig slurry treatments.

References

1] Brennan, R.B., Healy, M.G., Grant, J., Ibrahim, T.G., Fenton, O. 2012. Incidental phosphorus and nitrogen loss from grassland plots receiving chemically amended dairy cattle slurry. Science of the Total Environment, 441, 132-140.

Keywords

Slurry, chemical amendment, phosphorus, nitrogen, greenhouse gas