High rates of surface-applied FGD-gypsum decrease soil P availability under short-term flooding

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Introduction

FGD-gypsum, a calcium sulphate hydrate by-product of the flue gas desulfurization process, is commonly used by farmers as soil conditioner mainly to increase the amount of Ca and S to the soil and plants. FGD-gypsum has been largely used to amend well drained soils and it is not well known its effects on nutrients dynamic in soils that can experience short-term flooding and reducing conditions. Understanding the dynamic of nutrients during intermittent periods of soil saturation is vital for crops management and regulating water quality. In this study we sought to investigate the effects of surface applied FGD-gypsum on nutrients availability in the soil solution of Midwest US periodically flooded soils.

Method

Soil samples (10cm depth) of the Toronto-Millbrook complex soil (Udollic Epiaqualfs) were used in this study. The experiment consisted of the evaluation of 3 different FGD-gypsum treatments (0 (control); 1000 (G); 2000 (GG) kg ha^{-1}) and was performed in triplicate in an oxygen-free gas biogeochemical reactor where 80 g of sieved soil (2 mm) plus surface applied FGD-gypsum and 120 mL of degassed DI water were incubated in centrifuge bottles for 1,7,14, and 21 days of saturation at 25±0.5°C. Soil solution samples were collected after each incubation period in a glove bag saturated with N_2 gas then centrifuged, filtered (0.45 um), and analyzed for Ca, K, Mg, P using an ICP-OES. Eh and pH were measured after 1hour and 21 days of saturation.

Results

The results showed the redox state decreased up to -326 mV, whereas, the pH increased from 7 to 7.8 during the 21 days incubation period. This indicates that strongly reducing conditions were achieved during the experiment.

K, Mg, and Ca concentrations increased during the incubation period for the FGD-gypsum amended samples however, no clear trend was observed for the control treatment (Figures 1, 2, and 3).

The concentrations of P increased after 7 days of saturation for all treatments. After 14 days, P concentration remained unchanged for the FGD-treatments (Figure 4).

A high linear correlation was found between P and Ca for the highest FGD-gypsum rate treatment (Figure 5) but no correlation between P and Ca was found for the other two treatments.

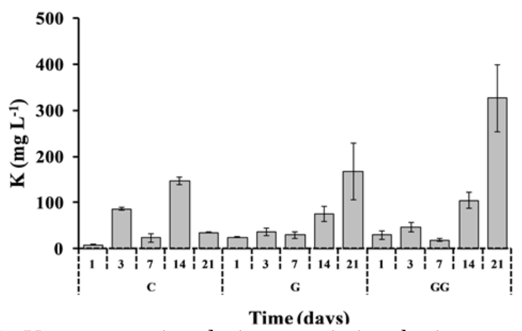

Figure 1. Changes in K concentration during anoxic incubation.

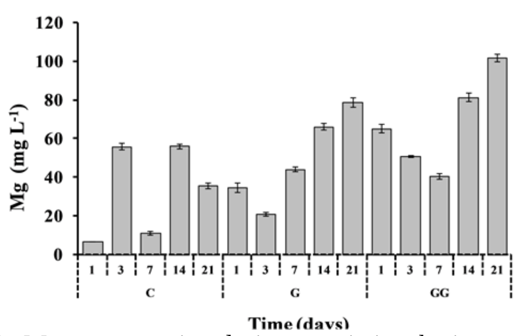

Figure 2. Changes in Mg concentration during anoxic incubation.

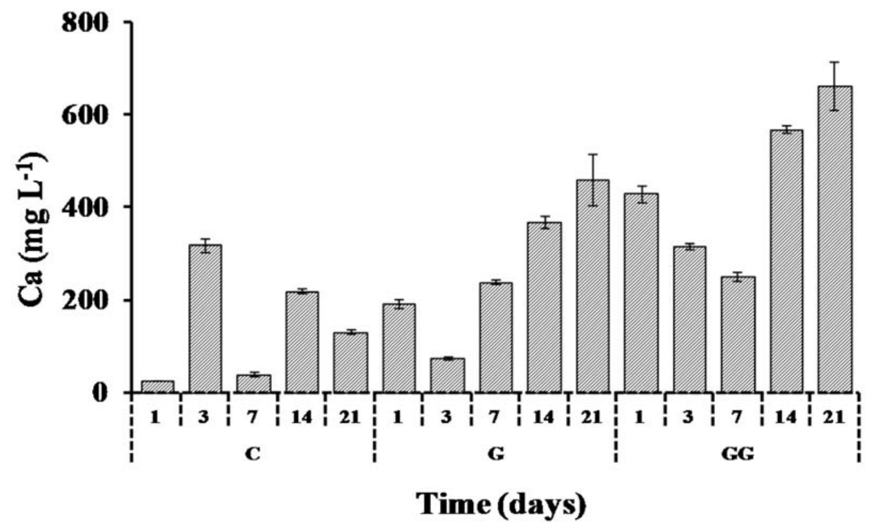

Figure 3. Changes in Ca concentration during anoxic incubation.

Figure 4. Changes in P concentration during anoxic incubation.

Figure 5. Simple linear regression between P and Ca. Data points are average of triplicates.

Discussion

The observed high correlation between P and Ca indicates that high rates of surface applied FGD-gypsum can control P concentration in the soil solution. A possible explanation is that the soil solution for the highest FGD-gypsum rate treatment was supersaturated with respect to Ca. Excess Ca could bind P thus allowing calcium phosphate to be formed and decreasing solution Ca and P concentrations since the beginning of the experiment.

Conclusion

High rates of FGD-gypsum can control soil P availability and this may imply substantial modifications in the soil solution chemistry and potential impact on offsite water quality.