From Forest Nursery Notes, Winter 2012

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Compost Science & Utilization, (2011), Vol. 19, No. 3, 197-204

Adsorption of Phosphate by Goethite and Zeolite: Effects of Humic Substances from Green Waste Compost

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Compost is widely used as a natural soil conditioner and fertilizer supplement in gardening, planting and agriculture. Ability of compost to retain and release nutrients over time offers potential use for control of excessive nutrient release to the environment; this ability may be further improved by the addition of adsorbents to facilitate rapid retention of nutrients. Therefore, we investigated the effects of humic substances extracted from green waste compost on the adsorption of phosphate by goethite (a-FeOOH) and zeolite ($SiO_2.Al_2O_3$). Humic acid (4.66% by dry-weight) and fulvic acid (1.26% as carbon/w) were extracted from finished compost and purified. The adsorption capacity of goethite (1.18 mmol/g) was slightly higher than zeolite's capacity (1.03 mmol/g). On the other hand, capacity of humic acid was determined much lower (0.51 mmol/g). The addition of fulvic acid resulted in a substantial reduction of adsorption capacities of all three adsorbents. Addition of 5.0 mmol/L of fulvic acid (as carbon) decreased the adsorption capacity of phosphate by goethite, zeolite and humic acid by 94%, 88% and 82%, respectively. Results of kinetics study indicated that the adsorption data fit the first-order kinetic model well with goethite exhibiting higher kinetic constants. The results of this study suggest that metal oxide adsorbents such as goethite could be applied as additives into compost to improve the nutrient holding ability.

Introduction

Presence of phosphorus in the environment continues to be of a great concern. Fahidi and Armanfar (2003) and James *et al.* (2007) are examples of who documented the negative impact of excessive phosphorous in water streams. In addition, Jones *et al.* (1995) reported that excessive phosphorous could also have a negative impact on growth of selected plants. Therefore, the removal of phosphorous, which is mainly released to the environment in the form of phosphate through surface runoff, receives considerable attention. Various metal salts and natural adsorbents have been applied to reduce the amount of phosphorus by fixing it to the support media (Aguilar *et al.* 2002; Barreal *et al.* 2001; Seida and Nakano 2002; Kang *et al.* 2003; Tanada *et al.* 2003; Zeng *et al.* 2004; Onyango *et al.* 2007; Genz *et al.* 2004). In this case, the availability of phosphorus to plants is considerably reduced. Furthermore, metal oxides tend to form fine particles that require additional processes for their subsequent removal from aqueous phase. To overcome this problem, James and Richard (1986) suggested using polymers as a holding media to prevent mobilization of phosphorous-fixed particles. Compost could potentially be used as the natural holding media for additives like iron oxides and zeolites to reduce the phosphate leaching from compost.

Certain factors including pH, ionic strength and presence of competitive ions have been shown to influence the adsorption of phosphate (Antelo *et al.* 2005, 2007; Geelhoed *et al.* 1997). In addition, Gerke (1993), Borggaard *et al.* (2005) and Guan *et al.* (2006) reported that dissolved humic substance (*e.g.* fulvic acid) exhibits a competitive adsorption with phosphate on the iron oxides or aluminum oxides. On the other hand, the undissolved humic substance (e.g. humic acid) could potentially contribute to the adsorption of contaminants, including excessive phosphate (Kang and Xing 2005; Martinez *et al.* 1984; Satisha *et al.* 2005; Sibanda and Yong 1986).

Compost is commonly used as the soil conditioner and fertilizer supplement. Increasing the ability of compost to quickly capture and retain phosphorous, then slowly release it over time would be a great advantage for control of phosphorous in the environment. To this end, natural adsorbents (e.g. goethite, zeolite, gypsum) are suggested to be added to compost to improve the retention and slow release of nutrients.

So far, literature regarding the effects of organic matter and metal oxides in compost on the fate and nutrients is very limited. Therefore, we investigated the effect of humic and fulvic acids extracted from compost on the adsorption of phosphate by goethite and zeolite.