Redox chemistry and nutrient release from organic amended sub-tropical soil under anaerobic incubation

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Introduction

Biogas technology mainly from animal and municipal wastes is one of the promising renewable energy resources for Bangladesh and becoming more popular over time. In 2017, more than 71,396 biogas plants of varying gas-producing capacities (2-6 m^3) were generating more than 5,71,168 tonnes (dry weight basis) of slurry (Islam, 2006, Islam et al, 2017). The byproduct or slurry from biogas plant can be used as manure for crop production (Abubaker et al., 2012). Proper application of bioslurry to crop land may help to improve soil organic matter status by adding humus, enhance soil's capacity for retaining water, increase supply of carbonaceous materials leading to biological transformations e.g. mineralization, nitrification and denitrification. Hence, bioslurry is an importance source of increasing organic matter in soil. However, in Bangladesh its use in crop production has not yet been analyzed critically. Therefore, the present research work was undertaken to examine the changes in pH and Eh values and to study N, P and S release from different manure and bioslurry amendments in sub-tropical soil under anaerobic incubation.

Methodology

The incubation study was conducted with a silty clay soil (Ultic Ustocrepts) having pH 3.7, total N 0.1%, Olsen P 33.9 mg kg^{-1}, available S 12.9 mg kg^{-1} and organic carbon 0.92%. Approximate mineralogical composition of the soil was mica 39%, quartz 19%, kaolinite 16%, chlorite 13% and feldspar 9% (Kader et al., 2015). The anaerobic incubation was laid out in a complete randomized design with three replications and five treatments viz. control, poultry manure, poultry bioslurry, cowdung and cowdung bioslurry. The soil was amended with all the treatments at 2 g $100g^{-1}$ (air dry basis) soil and incubated for 14 weeks at 25° C. The bulk density of the soil in the container was adjusted to the field density by compacting the soil to 1.2 Mg m^{-3} and were over saturated with a standing water level of 2 cm. The N, P and S release were estimated by the measurement of NH_4-N, phosphate P and SO_4-S on destructive sampling every two weeks.

Results and discussion

The pH values increased initially but gradually decreased over time to neutral. Redox potential declined over the first 1-3 weeks of incubation depending on the quality of organic matter used for soil amendments. Overall, when the pH values were averaged over the weeks, the highest pH value was measured in poultry bioslurry amended soil followed by poultry manure, cowdung bioslurry and cowdung amended soils and the lowest was in control. The higher pH value of poultry bioslurry and poultry manure amended treatments can be attributed to the fact that poultry feeds are very Ca and lime rich. The redox potential showed a significant variation among the treatments (Fig 1). When the Eh values were averaged over the weeks, the most negative (-133) Eh value was measured in poultry manure-amended soil followed by poultry bioslurry, cowdung and cowdung bioslurry amended soils. Control soil had the least negative Eh value. However, among the organic amendment, poultry manure and poultry bioslurry showed the most negative Eh value compared to cowdung and cowdung bioslurry. This might be due to the quality of amended organic manure. Organic manure rich in particulate organic matter is decomposed very quickly which triggered the decrease in Eh. Here studied poultry manure was fresh and composed of very labile organic matter. On the contrary, cowdung and cowdung biolsurry were comparatively more decomposed and hence triggered less microbially-induced reduction of the soil during incubation. At the end of incubation, the highest amount of NH_4-N was found in cowdung bioslurry followed by cowdung, poultry manure, poultry bioslurry and the lowest was in control; the highest amount of phosphate-P was found in poultry bioslurry followed by poultry manure, control, cowdung bioslurry and cowdung; the highest amount of SO_4-S was in soil amended with poultry bioslurry followed by poultry manure, cowdung bioslurry, cowdung and the lowest was in control. The results showed that the ammonification rate was smaller in bioslurry-amended soil compared to manure-amended soil. This is particularly true for poultry manure and poultry bioslurry treatments. This might be due to the higher pH of poultry bioslurry that enhanced volatilization losses of evolved NH_4-N (Bitzer and Sims, 1988). Poultry feeds are rich both in organic and inorganic P. Poultry is unable to digest phytate-P that dominate the organic P fraction in poultry feedstuff due to lack the phytase enzyme in their digestive systems (Sims and Vadas, 1997). Thus, much of the total P passes through the birds and ends up in the litter, increasing litter P concentrations. Much higher total S content for poultry manure and poultry bioslurry as well as

narrower C:S ratio of poultry manure and poultry bioslurry might be reason of this higher rate of S release compare to the cowdung and cowdung bioslurry (Reddy *et al.,*2002).

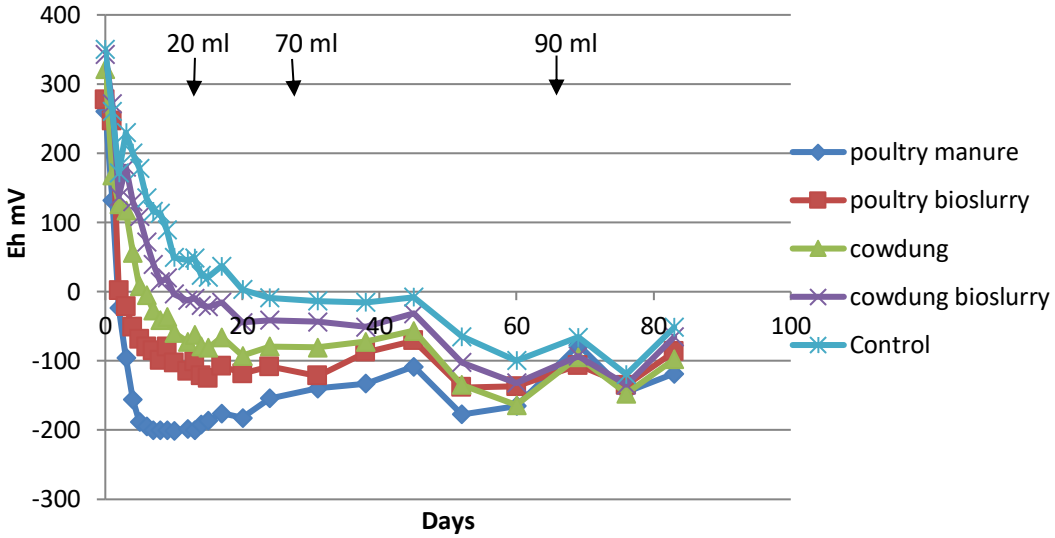

Figure 1: Eh values in terrace soil as influenced by different organic materials during 14 weeks of incubation.

Conclusions

The quality of organic materials as well as soil itself have a large influence on the changes of pH, Eh and nutrient releases during anaerobic incubation. The reduction potential (Eh) of the studied soil showed a significant variation among the treatments depending on the chemical composition and quality of organic matter used for soil amendments. Soil pH was increased by the lime content of the applied organic materials while the Eh was decreased by the liability of applied organic materials. Based on the present study, it may be concluded that application of bioslurry in soil had better performance on release of N, P, S, and the use of manure in soil not only accelerated the release of nutrients but may also maintain soil pH and soil Eh. The results suggest that soil should be amended with bioslurry of poultry manure or cowdung to improve fertility rather than decomposed manure or dung.

Keywords: Bio-slurry, Soil pH, Soil Eh, nutrient release, anaerobic incubation.

References

Abubaker J, Risberg K, Pell M (2012) Biogas residues as fertilisers-effects on wheat growth and soil microbial activities. *Applied Energy* 99, 126–134.

Bitzer CC, Sims JT (1988) Estimating the availability of nitrogen in poultry manure through laboratory and field studies. *Journal of Environment Quality* 17**,** 47–54.

Islam MS 2006: Use of Bioslurry as Organic Fertilizer in Bangladesh Agriculture. Prepared for International Workshop on the use Bioslurry for Domestic Biogas Programmes 27th-28th September, Bangkok, Thailand.

Islam MS, Islam MR, Das BK, Hoque N (2017) Assessment of Biogas Resources for Rural Electrification in Bangladesh. International Conference on Mechanical, Industrial and Materials Engineering 2017(ICMIME2017)28-30 December, 2017, RUET, Rajshahi, Bangladesh.

Reddy KS, Singh M, Swarup A, Rao AS, Singh KN (2002) Sulphur mineralization in two soils amended with organic manures, crop residues and green manures. *Journal Plant Nutrition Soil Science* 165 (2), 167-171.

Sims JT, and Vadas PA (1997) Soil test phosphorus status and trends in Delaware. Fact Sheet ST-09. Univ. Delaware, Newark, DE.