Biosolids as soil-amendment: evaluation of nutrient leaching in loamy-silty soil

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Abstract

Sewage sludge (SS) is a by-product of wastewater treatment. Anaerobic digestion is a worldwide technology used in SS stabilization and pre-treatment step is used to improve its biodegradability. Once SS is stabilized they are named biosolids (BS). Biosolids composition makes them attractive as a soil amendment. But also, BS could be a source of contamination. Therefore, the objective of this study was to evaluate the nutrient leaching in loamy-silty soil of BS stabilized with conventional and advanced anaerobic digestion. Thus, two biosolids from conventional and advanced anaerobic digestion were evaluated in soil leaching columns using loamy-silty soil to evaluated phosphorus and nitrogen flux. The results show that the leaching rate of nutrients is not influenced by the pre-treatment, but the application rate of biosolids influences the leaching rate of nutrients.

Keywords: pre-treatment, advanced anaerobic digestion, waste management, sewage sludge

1 Introduction

Municipal sewage sludge (SS) is a by-product of wastewater treatment. The amount of SS has increased with the construction and expansion of wastewater treatment plants, while stricter policies have limited its disposal. These must be stabilized because their content of putrescible organic matter, pathogens, and the large volume generated. Once SS is stabilized they are named biosolids (BS). Anaerobic digestion is a worldwide technology used in SS stabilization. However, SS complexity makes hydrolysis a limiting step in anaerobic digestion; so a pre-treatment step has been incorporated to enhance the process (Neumann *et al.*, 2016). The BS composition makes them attractive as a soil amendment (Alvarenga et al., 2017). The use of BS on soil offers economic and environmental benefits because they: a) allow the recycling of micro- and macronutrients (nitrogen, phosphorus, and potassium); b) enhance soil organic carbon storage; c) promote the formation of stable aggregates; d) improve water holding capacity, soil cationic exchange and aeration and e) promote erosion resistance. (Alvarenga et al., 2017; Antilén et al., 2014). But also, BS could be a source of contamination with heavy metals, eutrophication of water bodies due to nutrients content and risks associated with pathogenic microorganisms and micropollutants (Wu et al., 2015). Therefore, the objective of this study was to evaluate the nutrient leaching in loamy-silty soil of biosolid stabilized with conventional and advanced anaerobic digestion.

2 Materials and Methods

Two types of BS were used; one came from conventional anaerobic digestion (CAD) and the other ones from advanced anaerobic digestion (AAD). The pre-treatment in AAD consists of ultrasound using specific energy of 2000 kJ/ kg of ST (Neumann *et al.*, 2018). Two application rates, 30 and 90 ton/ha, of BS was evaluated. The system was evaluated during 11 weeks in soil leaching columns using loamy-silty soil to be evaluated phosphorus and nitrogen flux. The leaching columns were 25 cm high and 7.2 cm of diameter. Every 48 h a rain simulation flux of 29 mL of distilled water was added. Then the leaches were collected and analyzed physiochemically according to standard methods methodology (APHA, 2005).

3 Results and Discussions

For the use of biosolids as soil-amendment, a holistic approach is needed. Previous results showed that these biosolids could be applied as a soil amendment considering metal content and phytotoxicity assay (Venegas et al., 2018). Therefore, nutrient leaching is an important issue for the evaluation of biosolids for land application. Table 1 shows the characterization of the soil and the biosolids.

Table 1. Physicochemical characterization of the soil and biosolids

Parameter	Units	Soil	SP	CP
pH	-	6,40±0,40	7,15±0,11	7,05±0,20
COD_s	g/L	0,34±0,13	18,01±8,32	21,47±7,23
OM	%	6,98±0,45	67,89±0,23	64,54±0,19
N_t	mg/L	38,0±10,6	366±26	375±100
TKN	mg/L	8,07±0,01	244±105	253±78
NH_4^+-N	mg/L	1,18±0,88	54±2	64±10
NO_2^--N	mg/L	0,40±0,03	5,74±1,37	6,73±3,29
NO_3^--N	mg/L	42,42±9,30	8±0,6	26±9
P_t	mg/L	0,75±0,45	65±01	80±1
PO_4^--P	mg/L	0,34±0,01	47±4	76±12

SP: biosolids from anaerobic digestions without pre-treatment; CP: biosolids from anaerobic digestions with pre-treatment; COD_s: soluble chemical oxygen demand; OM: organic matter; N_t: total nitrogen; TKN: Total Kjeldahl Nitrogen; P_t: total phosphorus.

The leaching of phosphate varies between 0.001-0.006 mg, this low concentration in the leaching is consistent with the low mobility of this element in soil. Also, there is no significant difference ($p>0.05$) between the total phosphorus leaching from the system SP90 and CP90 (application rate of 90ton/ha). Same behavior for SP30 and CP30 system (application rate of 30 ton/ha).

Figure 1 shows the total nitrogen and phosphate in the leach. There is no significant difference ($p>0.05$) between the total N_T leaching from the system SP90 and CP90. Same behavior for SP30 and CP30 system.

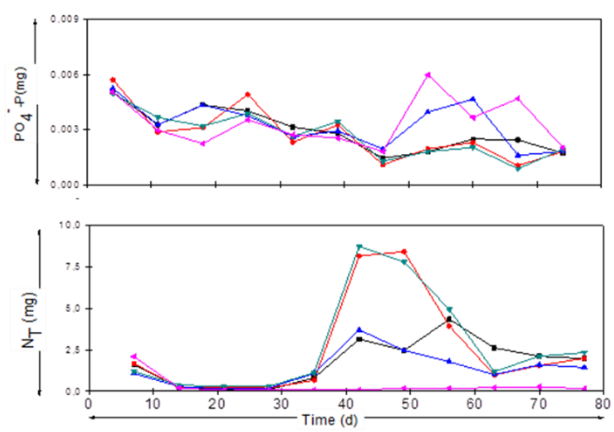

Figure 1. Mass of total nitrogen and phosphate in the leach. SP30(■): without pre-treatment at 30 ton/ha; SP90(●): without pre-treatment at 90 ton/ha; CP30(▲): with pre-treatment; CP90(▼): without pre-treatment at 90 ton/ha; Control (◀): only soil.

The N_T increase between 35 to 60 days is related to an increase in the amount of nitrate coming from the nitrification of BS (Figure 2).

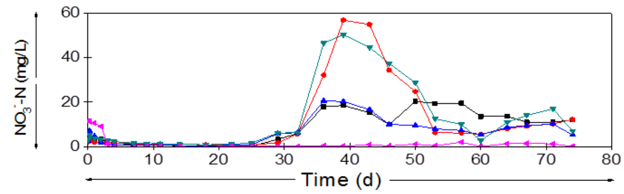

Figure 2. Leaching ratio of nitrite. SP30(■): without pre-treatment at 30 ton/ha; SP90(●): without pre-treatment at 90 ton/ha; CP30(▲): with pre-treatment at 30 ton/ha; CP90(▼): without pre-treatment at 90 ton/ha; Control (◀): only soil.

4 Conclusion

The leaching rate of phosphorus and nitrogen are not influenced by the pre-treatment ($p>0.005$), but the application rate influences the leaching rate of these nutrients.

Acknowledgments

This work was supported by CONYCYT/FONDAP/15130015. M. Venegas thanks to CONICYT for her Scholarship Program CONICYT-PCHA/Doctorado Nacional/2016-21160100, for supporting her Ph.D. studies at the University of Concepción.

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