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Exploring the potential of urban sewage sludge for liquid humus production

Explorando el potencial de lodos urbanos para la producción de humus líquido

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ABSTRACT

Worldwide, scientists have long been researching municipal sewage sludge management options in the context of the circular economy. In Chile, in particular, there have been a lot of misgivings about the disposal of sewage sludge. Liquid humus is a solution of humic and fulvic acids that can be used to add organic matter to soil via irrigation. The objective of this study was to evaluate the industrial potential of sewage sludge as a source material for the production of liquid humus. The sludges analyzed in the study produced liquid humus with high concentrations of humic and fulvic acids (7.3–7.9 g L^{-1}). In one sludge under study, humic acids constituted the principal ingredient, while in another sludge, humic and fulvic acids were found in similar proportions. Since the results point to the occurrence of sewage sludge humification, such sludge from wastewater treatment plants may potentially be used as a source for the production of liquid humus. However, future studies are needed to evaluate agronomical performance of liquid humus sourced from urban sewage sludge.

RESUMEN

A nivel mundial, los científicos han estado investigando las opciones de gestión de lodos urbanos en el contexto de la economía circular. En Chile, en particular, ha habido muchas dudas respecto a la eliminación de lodos de aguas servidas. El humus líquido es una solución de ácidos húmicos y fúlvicos que se puede utilizar para añadir materia orgánica al suelo a través del riego. El objetivo de este estudio fue evaluar el potencial industrial de lodos urbanos como fuente para la elaboración de humus líquido. Los lodos analizados en el estudio produjeron humus líquido con altas concentraciones de ácidos húmicos y fúlvicos (7,3–7,9 g L^{-1}). En un lodo estudiado, los ácidos húmicos constituían el ingrediente principal, mientras que, en otro lodo, los ácidos húmicos y fúlvicos se encontraban en proporciones similares. Dado que los resultados apuntan a la existencia de humificación en lodos urbanos, tales lodos de las plantas de tratamiento de aguas servidas pueden potencialmente utilizarse como fuente para la producción de humus líquido. Sin embargo, se necesitan futuros estudios para evaluar el desempeño agronómico del humus líquido proveniente de lodos urbanos.

Palabras clave: materia orgánica, ácidos húmicos, ácidos fúlvicos, humus líquido, sustancias húmicas, lodos urbanos.

INTRODUCTION

Humus is an important fraction of soil organic matter that is characterized by enduring stability (Tan, 2014). It is composed of humic and fulvic acids as well as humin. At present, aqueous solutions called "liquid humus" have been developed to supply the same benefits to the soil and crops through irrigation systems as those that traditionally were delivered by means of solid organic amendments (Fataftah *et al.*, 2007, Ortega and Fernandez, 2007).

In Chile, in particular, there is great inquietude about the disposal of sewage sludge (Secretaría General de la Presidencia, 2009), in part, because sewage sludges can carry a high pathogenic load (e.g., Ogleni and Ozdemir, 2010) and large concentrations of toxic metals (e.g., Mossa *et al.*, 2017), which makes their use uneconomic, especially in direct applications to agricultural soils. However, pathogenic load in sewage sludges can be reduced by means of alkaline treatments (US EPA, 2003). In fact, liquid humus extraction from bioso-

lids by means of an alkaline treatment can produce humic solutions with low pathogenic loads. Furthermore, given that metals are less soluble in alkaline medium (McBride, 1994), alkaline extraction from biosolids can deliver humic solutions with low metal content.

It is on this basis that this study set out to evaluate the potential of wastewater treatment sludge as a source for the production of liquid humus.

MATERIALS AND METHODS

The sewage sludges used in this study were collected from Aguas Andinas S.A. (Metropolitan Region, Chile) wastewater treatment plants in May of 2006. The following sludges were used in this study: Paine centrifuged (P-C) and Trebal sun dried (T-SD). The humic acid (HA) and fulvic acid (FA) content in the sludges was determined based on the humus fractioning method described by Orlov and Grishina (1981). This method consists in separating the humic and fulvic acids (HFA) in an alkaline medium (0.1 M NaOH + 0.1 M $Na_2H_2P_2O_7$) followed by separation based on differences in solubility at different pHs. The HFA solution thus obtained was then acidified with 1 N H_2SO_4, causing the humic acids to precipitate, while the fulvic acids remained soluble in the acid medium. Afterward, the HA was again dissolved in an alkaline medium. The HFA concentrations were determined using the dichromate oxidation method in an acid medium and colorimetric determination of reduced chromate (Sadzawka *et al.*, 2006).

A previous study (Orlov and Grishina, 1981) has recommended the use of NaOH + $Na_2H_2P_2O_7$ for the extraction of HFA. However, due to the harmful effects of sodium on soil structure (Sparks, 2003), we decided to evaluate 0.01 M KOH and 0.01 M $Ca(OH)_2$ as a medium of HFA extraction from sludge, and the evaluation was performed according to the methods described above. The low concentrations of both extraction agents were chosen to minimize salt damage to soil. The concentrations of HFA were determined as a function of time that the sludge was exposed to the extractants. The HFA concentrations obtained with $Ca(OH)_2$ were much lower than those achieved with KOH (Merino, 2007), thus it was eliminated as a potential extractant.

The liquid humus was made by pouring the sludge in a 2 L beaker for precipitation, to which 0.01 M KOH was added (pH 12), with a sludge/extractant proportion of 1/1. The suspension was left to rest for 96 hours, after which the contents were filtered to obtain liquid humus. Preliminary tests demonstrated that the maximum extraction of HFA was achieved after 96 hours of exposure (Merino, 2007).

RESULTS AND DISCUSSION

The sludges analyzed in this study produced liquid humus with high concentrations of humic and fulvic acids (7.3-7.9 g L^{-1}, Table 1). The humic acids corresponded to the principal fraction of the P-C, while for the T-SD, humic and fulvic acids were found in similar proportions. The results reveal the occurrence of humification in sewage sludge. This correlates with the results of Li *et al.* (2014) who reported on the extraction of humic and fulvic acids from sewage sludge by alkaline treatment.

Most of commercial liquid humus is obtained from leonardite (the oxidized form of carbon of lignitic origin) (e.g., Sun *et al.*, 2020). Our preliminary study (Merino, 2007) suggests that liquid humus derived from sludge is as efficient in increasing soil aggregate stability index as commercial liquid humus derived from leonardite. Interestingly, this echoes the results of Ortega and Fernandez (2007) who found no considerable differences between liquid humus obtained from earthworm humic substances and leonardite-based products. Furthermore, Ortega and Fernandez (2007) claimed that earthworm humic substances represent a more sustainable alternative as a source material for liquid humus production because of their renewable nature. In contrast, leonardite takes thousands of years to form, and, moreover, has never been found in Chile.

Scientists worldwide have long been researching options in the area of municipal sewage sludge management in the context of the circular economy (e.g., Rosiek, 2020). Although liquid humus extraction from urban sewage sludge represents an example of waste reutilization in the economy of circular character, the studies dedicated to this specific method are scarce

Table 1. Humic and fulvic acid concentrations in liquid humus obtained from urban sewage sludge.
Cuadro 1. Concentraciones de ácidos húmicos y fúlvicos en el humus líquido obtenido de lodos urbanos.

Humus	HFA (g L^{-1})	HA (g L^{-1})	FA (g L^{-1})	HA/FA ratio
P-C	7.9	6.7	1.2	5.6
T-SD	7.3	3.4	3.9	0.9

HFA = humic and fulvic acids, HA = humic acids, FA = fulvic acids.

(Norambuena *et al.*, 2014). Future studies are required to evaluate the agronomical properties of liquid humus obtained from urban sewage sludge to be able to compare the results with those from leonardite-based products (e.g., Akimbekov *et al.*, 2020, Kaya *et al.*, 2020).

CONCLUSION

Sewage sludge from wastewater treatment plants can potentially be used for the production of liquid humus.

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REFERENCES

Akimbekov, N., Qiao, X.H., Digel, Y., Abdieva, G.Z.M., Ualieva, E.R.Z., Zhubanova, A.Z.R., 2020. The effect of leonardite-derived amendments on soil microbiome structure and potato yield. Agriculture-Basel 10, 147. https://doi.org/10.3390/agriculture10050147.

Fataftah, A.K., Watia, D.S., Gains, B. Kotob, S.I., 2007. A comparative evaluation of known liquid humic acid analysis methods, in: Ghabbour, E. A. and Davies, G., (Eds.), Humic substances: structures, models and functions. Royal Society of Chemistry, Cambridge, UK, pp. 337-342.

Kaya, C., Senbayram, M., Akram, N.A., Ashraf, M., Alyemeni, M.N., Ahmad, P., 2020. Sulfur-enriched leonardite and humic acid soil amendments enhance tolerance to drought and phosphorus deficiency stress in maize (*Zea mays* L.). Scientific Reports 10, 1–13. https://doi.org/10.1038/s41598-020-62669-6.

Li, H., Li, Y.K., Zou, S.X., Li, C.C., 2014. Extracting humic acids from digested sludge by alkaline treatment and ultrafiltration. Journal of Material Cycles and Waste Management 16, 93–100. https://doi.org/10.1007/s10163-013-0153-6.

McBride, M.B., 1994. Environmental Chemistry of Soils. Oxford University Press, New York, NY.

Merino, M., 2007. Estudio de efectos de dos humus líquidos sobre estabilidad de agregados. Facultad de Agronomía, Pontificia Universidad Católica de Valparaíso, Quillota, Chile.

Mossa, A.W., Dickinson, M.J., West, H.M., Young, S.D., Crout, N.M.J., 2017. The response of soil microbial diversity and abundance to long-term application of biosolids. Environmental Pollution 224, 16–25. https://doi.org/10.1016/j.envpol.2017.02.056.

Norambuena, M., Neaman, A., Schiappacasse, M.C., Salgado, E., 2014. Effect of liquid humus and calcium sulphate on soil aggregation. Journal of Soil Science and Plant Nutrition 14, 701–709.

Ogleni, N., Ozdemir, S., 2010. Pathogen reduction effects of solar drying and soil application in sewage sludge. Turkish Journal of Agriculture and Forestry 34, 509–515. https://doi.org/10.3906/tar-0908-300.

Orlov, D.S., Grishina, L.A., 1981. Manual de Laboratorio de Química del Humus. Ediciones de la Universidad Estatal de Moscú, Moscú, Rusia.

Ortega, R., Fernandez, M., 2007. Agronomic evaluation of liquid humus derived from earthworm humic substances. Journal of Plant Nutrition 30, 2091–2104. https://doi.org/10.1080/01904160701700574.

Rosiek, K., 2020. Directions and challenges in the management of municipal sewage sludge in Poland in the context of the circular economy. Sustainability 12, 3686. https://doi.org/10.3390/su12093686.

Sadzawka, A., Carrasco, M.A., Grez, R., Mora, M.L., Flores, H., Neaman, A., 2006. Métodos de análisis recomendados para los suelos de Chile. Serie actas INIA Nº 34. Instituto de Investigaciones Agropecuarias, Santiago, Chile.

Secretaría General de la Presidencia, 2009. Decreto Supremo 4. Reglamento para el manejo de lodos generados en plantas de tratamiento de aguas servidas. Santiago.

Sparks, D.L., 2003. Environmental Soil Chemistry. Academic Press, Amsterdam.

Sun, Q., Liu, J.L., Huo, L.F., Li, Y.C.C., Li, X., Xia, L.R., Zhou, Z.K., Zhang, M.N., Li, B., 2020. Humic acids derived from Leonardite to improve enzymatic activities and bioavailability of nutrients in a calcareous soil. International Journal of Agricultural and Biological Engineering 13, 200–205. https://doi.org/10.25165/j.ijabe.20201303.5660.

Tan, K.H., 2014. Humic matter in soil and the environment: principles and controversies. CRC Press, New York.

US EPA, 2003. Environmental regulations and technology. Control of pathogens and vector attraction in sewage sludge. EPA 625/R-92/013. US Environmental Protection Agency Cincinnati, Ohio.