ČESKÁ ZEMĚDĚLSKÁ UNIVERZITA V PRAZE
Katedra agroenvironmentální chemie a výživy rostlin

CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE
Department of Agro-Environmental Chemistry and Plant Nutrition

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Sborník z 27. mezinárodní konference

RACIONÁLNÍ POUŽITÍ HNOJIV

zaměřené na problematiku výživy a hnojení fosforem

Proceedings of 27th International Conference on

REASONABLE USE OF FERTILIZERS

dedicated to phosphorus nutrition and fertilization

ČZU v Praze
2. 12. 2021

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Katedra agroenvironmentální chemie a výživy rostlin ČZU v Praze

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AGROFERT

LOVOCHEMIE

Konference je zaměřena na významný makroelement – fosfor. Tento prvek je esenciální z hlediska výživy rostlin i zvířat, ale zároveň má značný vliv na kvalitu životního prostředí, zejména vod. S ohledem na omezená světová naleziště je zřejmé, že tento prvek je klíčový z hlediska dlouhodobé udržitelnosti rostlinné produkce v ČR i ve světě. Bude zde diskutována bilance P v rostlinné produkci, vývoj zásoby fosforu v půdách, hodnocení různých extrakčních metod, příjem fosforu rostlinami. Dále bude pozornost věnována fosforečným hnojivům, včetně využití P z odpadních látek (např. čistírenský kal upravený torefakcí a pyrolýzou), a samozřejmě moderním aplikačním technologiím.

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THE EFFECT OF VERMICOMPOSTING ON THE AVAILABILITY OF PHOSPHORUS IN SEWAGE SLUDGE MIXED WITH STRAW PELLETS

(Vliv vermikompostování na přístupnost fosforu v čistírenských kalech s přídavkem slaměných pelet)

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Abstract

The anticipated global phosphate shortage has compelled the search for alternative P fertilizer resources. As a result, the focus of this study is on the turnover of phosphorus (P) derived from sewage sludge (SS) mixed with different proportions of pelletized wheat straw (PWS) as affected by vermicomposting. The experiment included four treatments with three replications: (T1) 100% SS, (T2) 75% SS + 25% PWS (w/w), (T3) 50% SS + 50% PWS (w/w), (T4) 25% SS + 75% PWS (w/w). After 14 days of pre-composting, the substrate was homogenized and transferred to worm bins for subsequent vermicomposting. Each worm-bin received 377 pieces of adult earthworms (*Eisenia andrei)*. The concentration of total P (F =37.81, p = 0.000) significantly increased with an overall increase of 31%, 42%, 41% and 56% for T1, T2, T3, and T4 respectively and available P (F = 3.2, p = 0.03) significantly increased in all treatments during vermicomposting with an overall increase of 60%, 60%, 73% and 81% for T1, T2, T3, and T4 respectively. The available P from total P was increased by 3.96%, 4%, 8.06%, and 13.80% for T1, T2, T3, and T4, respectively. As a result, these findings indicate that vermicomposting of SS mixed with PWS increased phosphorus availability.

Key words: biowaste; P fertilizer; P solubilisation; organic P; organic matter

The annual phosphorus (P) input required for agriculture in the European Union (EU) has been estimated to be 3.85 million tons (P_2O_5) [1]. The majority of this requirement is currently met by inorganic P fertilizers derived from mined phosphate rocks a non-renewable resource that is becoming increasingly scarce [2]. As a result, alternative P sources are desperately needed, and P-rich organic residues should be considered. In the EU, more than 10 million tons of sewage sludge (SS) with an average P content of 28 g/kg (dry matter) is generated each year [3]. As a result, this residue may be useful in reducing current reliance on phosphate rocks. However, SS used on land must not only meet established pollution standards, but also undergo a pre-treatment that kills potential pathogens and reduces their fermentability. This can be accomplished through vermicomposting.

Vermicomposting is a well-known process for solid organic waste reclamation and the final product, vermicomposts, can be used as sources of organic matter for soil amendment, as sources of nutrients for soil fertilization, or as growing media constituents for soil cultivation [4]. The majority of previous vermicomposting studies focused on the feasibility of different organic wastes, the factors influencing earthworm growth and reproduction rates, and the quality of vermicomposts [5,6]. However, little is known about the availability of P during the vermicomposting of organic wastes, particularly sewage sludge, with varying additive materials. Therefore, the objective of this study is to evaluate how vermicomposting affects the turnover of phosphorus (P) derived from sewage sludge mixed with different proportions of pelletized wheat straw.

Material and methods

Raw materials and additive substances

Sewage sludge (SS) used in the experiments came from the wastewater treatment plant in the Czech Republic, and had a dry matter content of 13.3 %, pH-H_2O (6.99), EC (0.62 mS/cm), TC (32.95%), TN (5.36%), and C: N (6.15). Dried pelletized wheat straw (PWS) was provided by Granofyt Ltd Company with a diameter of 10 mm with a dry matter content of 21.4 %, pH-H_2O (8.3), EC (0.68 mS/cm), TC (42.5%), TN (0.8%), and C: N (53.2%). The experiment was carried out at the experimental station of the Faculty of Agrobiology, Food and Natural Resources, Czech University of Life Sciences Prague, in Červený Újezd.

Experimental setup and vermicomposting processes

The experiment included four treatments with three replications: (T1) 100% SS, (T2) 75% SS + 25% PWS (w/w), (T3) 50% SS (w/w) + 50% PWS (w/w), (T4) 25% SS + 75% PWS (w/w). The substrate was homogenized and transferred to worm-bins for subsequent vermicomposting for 120 days after being pre-composted for 14 days. Each worm-bin received 377 pieces of adult earthworms (*Eisenia andrei*).

Analysis of phosphorus

The phosphorus content was determined before vermicomposting, and then every 30 days during vermicomposting until the experiment was completed after 120 days. On every sampling event, three samples (150 g) were randomly taken from each replicated treatment. The total P levels was determined by decomposition, utilizing the dry method in a closed system with microwave heating using an Ethos 1 system (MLS GmbH, Germany), and the available P was determined using the CAT solution (0.01 mol/L $CaCl_2$ and 0.002 mol/L diethylene triamine pentaacetic acid (DTPA) at the rate of 1:10 (w/v), following the International standard procedures [7]. The total and available element concentrations were determined using inductively coupled plasma optical emission spectrometry (ICP-OES, VARIAN VistaPro, Varian, Australia) with axial plasma configuration.

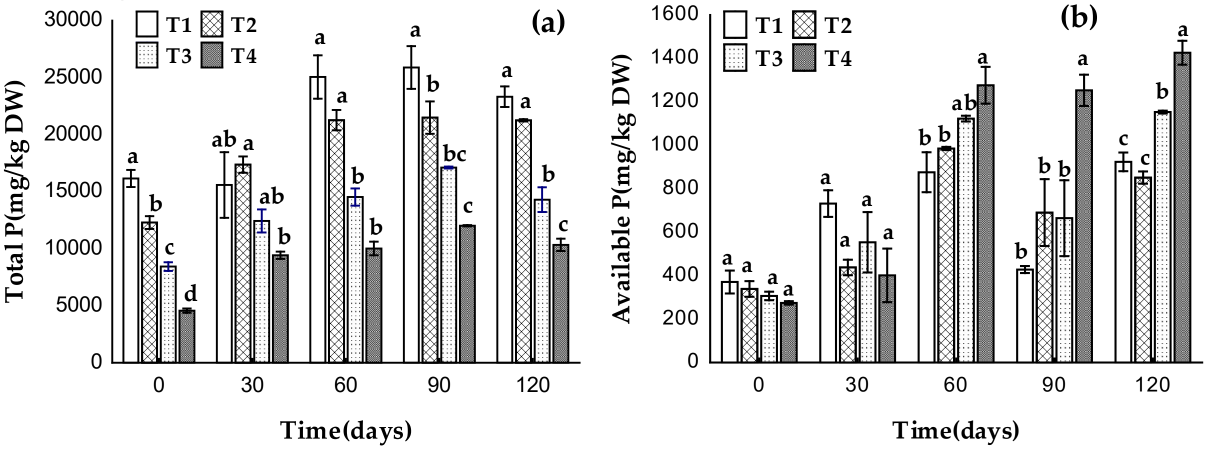
Statistical analyses

The statistical analyses were carried out using Statistica 12 software (StatSoft, USA). The means of the three replicates were used to calculate all of the results. Analysis of variance (ANOVA) was used to test the significant sources of variation, and the following Tukey HSD test was used to compare the treatment means if the factors' effect was significant at ($p < 0.05$).

Results and discussion

The total and available content of P in all treatments of vermicomposting are shown in Fig. 1. The concentration of total P ($F = 37.81$, $p = 0.000$) significantly increased with an overall increase of 31%, 42%, 41%, and 56% for T1, T2, T3, and T4 respectively and available P ($F = 3.2$, $p = 0.03$) significantly increased in all treatments during vermicomposting with an overall increase of 60%, 60%, 73% and 81% for T1, T2, T3, and T4 respectively. Based on it, the available phosphorus from total phosphorus was increased by 3.96%, 4%, 8.06%, and 13.80% for T1, T2, T3, and T4, respectively.

1. Variations of total (a) and available phosphorus (b) between different treatments and durations of vermicomposting. The bars indicate the standard error of the mean (n=3). Different letters indicate significant differences among the treatments (*p<0.05*).



After the 120 days of vermicomposting, the final total P values were increased from initial of 16170 to 23330 mg/kg, 12300 to 21270 mg/kg, 8437 to 14310 mg/kg, and 4573 to 10340 mg/kg, respectively for T1, T2, T3, and T4 from which about from initial of 371 to 924 mg/kg, 339 to 852 mg/kg, 307 to 1153 mg/kg, and 275 to 1427 mg/kg were the available P. The highest value of total P was found in treatment (T1) and available P was found in the treatment (T4), but the lowest was found in treatment (T4) for total P and in treatment (T2) for available P. The increase in available P may be attributed to the presence of earthworm gut phosphatase, and phosphorous solubilizing microorganisms in the worm casts that enhance the release of phosphorus in various forms [8]. Furthermore, mineralization and mobilization of organic matter by the combined effect of microorganisms, as well as phosphate excretion by earthworms, may have increased P content in the final vermicompost [9]. The reduction of pH could also have enhanced the solubilization of phosphorous and release of organically bound phosphate and thus increased its concentration in the final product [10]. Furthermore, the final pH values in these findings decreased from 6.9 to 5.7, 7.3 to 5.2, 7.6 to 6.0, and 7.9 to 5.8 for T1, T2, T3, and T4, respectively. This argument is corroborated by Ghosh *et al.* [11], who reported the presence of phytase enzymes in vermicompost that enhance mineralization of phosphorus as time progresses.

Conclusions

The concentration of total P (F =37.81, p = 0.000) significantly increased with an overall increase of 31 - 56% and available P (F = 3.2, p = 0.03) significantly increased in all treatments during vermicomposting with an overall increase of 60-81%. The available P from total P was increased by 3.96 - 13.80%. This study concluded that sewage sludge can be reused and retreated as high-quality fertilizer for agricultural purposes, and that vermicomposting is useful for converting nutrient-rich sewage sludge into a high-value commodity such as biofertilizer, in addition to producing biomass of earthworms with high commercial value. Vermicomposting has been shown to improve the element content of phosphorus in sewage vermicompost. As a result, sewage sludge could be used as a biofertilizer, acting as an efficient soil conditioner for sustainable land restoration practices and a biodegradable fertilizer substance as opposed to chemically synthesized fertilizer, which is obviously harmful to the environment. As a result, these findings indicate that vermicomposting of SS mixed with PWS increased phosphorus availability.

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