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Editorial: New Processes for Nutrient Recovery From Wastes

Matias B. Vanotti[1]*, Maria C. García-González[2], Beatriz Molinuevo-Salces[2] and Berta Riaño[2]

[1] USDA-ARS, Coastal Plains Soil, Water and Plant Research Center, Florence, SC, United States, [2] Agricultural Technological Institute of Castilla y León, Valladolid, Spain

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Correspondence:
Matias B. Vanotti
matias.vanotti@usda.gov

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Editorial on the Research Topic

New Processes for Nutrient Recovery From Wastes

Global demand for mineral fertilizers is continuously increasing, while large amounts of organic wastes are being disposed without use as a resource, resulting in soil, water, and air pollution. Current trends of intensification, expansion, and agglomeration of livestock production result in a net import of nutrients that lead to a surplus in some production areas (Vanotti et al., 2019). Therefore, new processes and technologies to recover and re-use nutrients from both solid and liquid wastes are desirable to close the loop on the nutrient cycle in modern human society and address future scarcity of non-renewable nutrients and fossil-based fertilizers. Development of technologies for nutrient-reuse was identified as one of the main challenges in waste management within a circular economy (Bernal, 2017). Another main challenge in this context is to provide needed information for efficient substitution of mineral fertilizer with nutrients from organic wastes (Bernal, 2017). This Research Topic aims to present scientific progress regarding processes and technologies that allow recovery and re-use of nutrients from wastes, the selective recovery of mineral nutrients (ammonia and phosphates), the production of new organic fertilizers, and evaluation of their relative agronomic efficiency. The Research Topic comprises 13 articles, including 11 Original Research articles and 2 Reviews.

Solid-liquid separation up-front in a treatment train allows recovery of the organic compounds that can be used for manufacture of compost materials, peat substitutes, quick-wash phosphorus, and biochars (Vanotti et al., 2019). Vanotti et al. presents a multi-stage treatment system in a swine facility that used high-rate solid-liquid separation as a first step (capture of 90% TSS, 69% organic N, and 84% organic P), followed by biological treatment of the ammonia in the separated liquid fraction, and efficient calcium phosphate recovery in the absence of ammonia and alkalinity buffers. The system was operated full-scale for 7 years. This allowed documentation of water quality improvements and the halt of sludge accumulation in the converted swine lagoons. Ro et al. contribute with a connected paper that shows an additional environmental benefit of the same system: the reduction on ammonia emissions. Using open-path tunable diode laser (TDL) absorption spectroscopy, the total farm-level NH_3 emissions were reduced below minimum detection level. Szogi et al. presents the use of a Quick Wash (QW) process to mine the phosphorus that has accumulated for years in the sludges at the bottom of anaerobic swine lagoons in the USA. The QW process uses acidification of the organic solids to release the phosphate, and precipitation of the phosphate as calcium phosphate. The recovered product was amorphous calcium phosphate with P_2O_5 grades (33–35%) higher than rock phosphate, but with the advantage that there is no need for additional chemical treatment for its use as plant fertilizer.

The circular economy approach requires the transformation of organic wastes through treatment and their reuse in agriculture. An important aspect for effective reuse of the new products is to know their relative agronomic efficiency and pollution risks compared to that of a mineral fertilizer. Santos et al. assessed the fertilizer value and the pollution risks of composts. The composts were prepared using mixtures of dewatered swine manure and cotton gin waste at ratios of 4:3 and 3:4. The compost with higher manure proportion was more efficient for N fertilization. However, both composts increased soil total N, soil available P, and plant biomass production and can be used as organic fertilizer to substitute mineral fertilizer, with the advantage of reduced nitrate leaching risk.

The production of biochars through pyrolysis or gasification processes could be an effective way of recycling the phosphorus (P) contained in organic materials. For both processes, the thermal conversion conditions and the type of biowaste are important factors that influence the subsequent physical and chemical properties of produced biochars. In fact, differences in their plant nutrient composition is the main concern with the use of biochar as a soil fertilizer amendment. In the present Research Topic, Novak et al. reported that pyrolized biochars produced from poultry litter feedstocks have significantly higher P and K contents than lignocellulosic-based biochars, and that various blends of feedstocks can be used to produce designer biochars that match specific crop nutrient needs. Li et al. studied the plant availability of P in five different gasification biochars and observed a strong influence of the type of feedstock on P availability. Specifically, gasification biochars derived from poultry manure, wheat straw and shea nut wastes presented higher P extractability relative to triple superphosphate (indicating the fertilizer value) than sewage sludge-based gasification biochars. In addition, Li et al. found that pyrolysis of poultry litter at 450°C or less significantly decreased the water-soluble proportion and lability of P in the biochar but did not affect the long-term P bioavailability. Under these conditions, they produced a P-enriched, slow release soil amendment that minimizes P runoff following field application and environmental risk of fertilization.

Gaseous ammonia (NH_3) emissions and a lack of N capture and reuse is a major concern in livestock farming today. In this Research Topic, three papers focus on technologies that could capture and recover the NH_3 emanating from manures. Oliveira Filho et al. and Molinuevo-Salces et al. studied a gas-permeable membrane (GPM) technology for reducing N content from liquid manures (digested and raw) and its recovery in a concentrated stable ammonium solution. The membrane manifolds are submerged and capture the NH_3 before it reaches the air. The studies used low-rate aeration to increase manure pH and promote NH_3 capture, contributing to NH_3 emissions mitigation and sustainable livestock waste treatment. Oliveira Filho et al. found that the GPM technology was efficient for recovering N from swine manure and effluents obtained by manure co-digestion with vegetable wastes; the NH_4^+ removal rate was >74%, and >95% of the removed N was recovered as a stable fertilizer salt solution. Molinuevo-Salces et al. showed that it is feasible to combine N-recovery by GPM technology and anaerobic digestion for the treatment of swine manure. The combined treatment resulted in a 96% ammonium recovery and a 69% total COD removal. A variety of valuable products was obtained, specifically sustainable energy in the form of methane and a stable ammonium sulfate solution for use in fertigation. Moore et al. used an innovative ARS air scrubber that captures NH_3 from exhausted air in animal feeding operations while simultaneously reducing emissions of dust and odor. Full-scale testing showed NH_3 capturing efficiencies over 90%. A variety of acid salts (alum, sodium or potassium bisulfate, ferric chloride, and ferric sulfate) were found to work as well as strong acids (hydrochloric, phosphoric, and sulfuric) for capturing NH_3.

Acién-Fernández et al. reviewed the relevance of microalgae-based processes for the recovery of nutrients from wastewaters. Under optimal conditions, up to 200 t per hectare and year of microalgae biomass can be produced containing 25 t of N and 2.5 t of P. Hernández et al. studied the recovery of N in the form of protein concentrates from this biomass that could be used for animal feed in aquaculture. The maximum protein recovery was 55% of the initial biomass protein. The left-over materials after protein extraction had value for methane (CH_4) production through anaerobic digestion, yielding 180 mL CH_4 g VS $^{-1}$.

Finally, Magrí used a bibliometric approach to review global trends in the area of knowledge of nutrient (N and P) management from digestates. The recovery of nutrients from digestates has undergone accelerated development in recent years. Physicochemical methods usually target the production of high quality, nutrient-rich concentrates that can be placed on the market.

The 13 articles composing this Research Topic provide a stronger recognition of the importance of nutrient recovery and upcycling in the new horizons of the circular economy.

AUTHOR CONTRIBUTIONS

MV and MG-G contributed to the conception and coordination of this Research Topic. All authors contributed to the writing of the present editorial article.

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