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Editorial

Innovative Animal Manure Management for Environmental Protection, Improved Soil Fertility, and Crop Production

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Traditionally, livestock manure has been used to provide nutrients for plant growth and to improve soil conditions. However, the increase in concentrated animal feeding operations (CAFOs) results in high levels of plant nutrients such as nitrogen and phosphorus in the proximal crop and pasturelands as a result of producing more manure than what is required to meet the local plant nutrient demand. Soil runoff and leaching of land-applied manure can enrich surface and ground water with nitrogen and phosphorus, leading to eutrophication and hypoxia. In addition, overapplication of animal manure can spread pathogens, release hormones and other pharmaceutically active compounds, and emit ammonia, greenhouse gases, and odorous compounds. In this Special Issue, we have 11 interesting articles on producing renewable energy and fuels, extracting ammonia from animal manures, the agricultural and environmental benefits from using animal manure or its derived materials such as biochar or ashes, and the difference in microbial communities and pathogen survival after anaerobic lagoon treatment.

Various innovative technologies to produce biogas, ethanol, and ammonia from livestock residuals are introduced in this Issue. Loughrin and Lovanh [1] reported that supplying a small amount of air into an anaerobic digester increased biomass production. Supplying up to 800 mL/d air to a 133-L poultry litter slurry increased biogas production by 73%; however, aeration at 2000 mL/d decreased biogas production by 19%. The research findings suggest that appropriate micro-aeration rates must be carefully determined in order to achieve optimal biogas production rates. Ro et al. [2] evaluated the preliminary economic feasibility of producing ethanol from agricultural, livestock, and forest residuals using commercially available gasification–synthesis gas fermentation technologies. A preliminary cost analysis of the integrated system was made for two cases, a regional scale of a 50 million gallon (50 MGY or 189,271 m^3) per year facility and a co-op scale (1–2 MGY) facility. The minimum ethanol selling prices (MESP) depend heavily on the facility size and feedstock costs. The MESP for the 50 MGY facility were significantly lower and comparable to current gasoline prices (USD 2.24–USD 2.96 per gallon or USD 0.59–USD 0.78 per liter) for the low-value feedstocks such as wood, wheat straw blended with dewatered swine manure, and corn stover.

Not only biogas and ethanol can be produced from animal manures, but also ammonia can be extracted directly from swine manure using membrane technology. Riano et al. [3] reported up to 90% recovery of total ammonia nitrogen (TAN) from swine manure using a gas-permeable membrane. They suggested that semi-continuous gas-permeable membrane technology may have a great potential for TAN recovery from animal manure. In addition, the ammonia recovery effectiveness of three types of gas-permeable membranes was investigated by Soto-Herranz et al. [4] These membranes were all made of expanded polytetrafluoroethylene (ePTFE), but with different diameters (3.0 to 8.6 mm), polymer densities (0.49 to 1.09), air permeabilities (2 to 40 L min^{-1} cm^2), and porosities (5.6 to 21.8%). While the ammonia recovery yields were not affected by the large differences in density, porosity, air permeability, and wall thickness, use of membranes with a larger diameter and corresponding larger surface area yielded higher ammonia recovery. A higher fluid velocity of the circulating acidic solution significantly increased ammonia recovery.

Considering the worldwide demands and increasing costs of synthetic fertilizers, the utilization of animal manures and their byproducts as sources of plant nutrients is regarded as a favorable alternative to improve farm income while restoring soil fertility and protecting the environment. Three articles in this Special Issue address the potential environmental impact of the use of manure byproducts as soil amendments regarding their efficacy as fertilizers, application distribution, and emissions of ammonia and greenhouse gases. In the first article, Bauer et al. [5] addressed the fertilizer value of incinerated poultry litter ash along with optimal land application methodologies. They evaluated the use of calcitic lime and flue gas desulfurization gypsum (FGDG) as potential fillers for land application of poultry litter ash. Application of ash alone or with fillers significantly increased soil extractable P and K levels above unamended controls by 100% and 70%, respectively. A field application distribution test suggested that uniform distribution of ash alone or with fillers is feasible with a commercial spinner disc fertilizer applicator. The two other articles report the effect of acidification of manure as a strategy to lower nitrogen losses due to ammonia volatilization. Spieh et al. [6] tested the acidifying effect of alum (aluminum sulfate) used as an amendment to abate emissions of ammonia losses along with greenhouse gases (methane and nitrous oxide), and hydrogen sulfide gas from cattle manure bedpacks. Their results indicated that an application of 10% alum is needed to effectively diminish ammonia emissions. While nitrous oxide emissions were not affected by the alum treatment, methane and hydrogen sulfur increased with the addition of alum. As a second alternative to conserve nitrogen, Szogi et al. [7] studied the use of low-phosphorus broiler litter, a byproduct of the Quick Wash process, designed to manage the surplus of nitrogen and phosphorus prior to soil application of broiler litter or animal manure. Their report shows that soil surface application of treated low-phosphorus litter appears as an option for slow mineral nitrogen release and abatement of ammonia and nitrous oxide soil losses.

Anaerobic lagoons are a conventional manure treatment for confined swine production systems in the Southeastern USA. Using a synthetic cover, these lagoons can be modified to capture the emission of ammonia and other malodorous compounds. Ducey et al. [8] assessed the potential of these covers to alter lagoon microbial communities under the assumption that alterations in the physicochemical makeup due to using a lagoon cover can impact the biological properties, most notably, the pathogenic populations. Their results show the addition of a cover had a significant impact on fecal coliform and *E. coli* levels, resulting in increased counts with respect to the uncovered, likely due to a reduction in solar radiation. From their microbial community composition that identified 200 bacterial families, they concluded that synthetic covers play a role in changing the lagoon microclimate, impacting lagoon physicochemical and biological properties.

Recycling and using raw materials from animal wastes that we generated are some of the environmental challenges that we face today. Promotion of innovative and appropriate technologies is necessary to achieve sound and sustainable animal manure management. Biochar production using pyrolysis technology can utilize most animal manures and many other recycled organics. Biochar is the solid product that results from pyrolysis of organic materials. Recycling of animal manure as a low-cost organic fertilizer has resulted in being a favorable effect on improving the yield of a variety of crops and promoted ecological and environmental functions of soils. The organic matter contents of pyrolyzed and/or composted animal manures is considerably high and its addition to agricultural soils improves soil physical, chemical, and biological properties.

Studies included in this volume highlight the effectiveness of pyrolyzed and composted animal manures as soil amendments in improving soil conditions that raised the agronomic values of soils. The incorporation of these organic amendments also improves the quality of contaminated mine soils and makes it possible for vegetation to be established. Karamat et al. [9] conducted a field plot study to investigate the impact of biochar and poultry litter alone or in combination on corn biomass, grain yield, nutrient uptake, and greenhouse gas emission for three growing seasons in Bowling Green, Kentucky. They reported that poultry litter application alone produced a significantly greater corn yield than biochar application, but similar to chemical fertilizer application. Addition of a fertilizer or poultry litter had a positive effect on reducing N_2O and CO_2 fluxes compared to fertilizer or poultry litter application alone. Additionally, there was a slight increase in grain yield in each year following biochar application and when biochar was mixed with poultry litter or fertilizers. Novak et al. [10] reported that designer biochars were able to improve important fertility properties in the sandy Goldsboro soil located in Florence, South Carolina. Despite the noted soil fertility improvement, corn grain and biomass yields were not significantly raised. The lack of significant improvement in corn yields in their study corroborates the results from other biochar field research projects conducted in temperate regions. They concluded that despite the Goldsboro soil being extensively weathered, it still possessed sufficient soil fertility traits that, with good agronomic practices and timely rainfall, can produce satisfactory corn yields.

The work of Sigua et al. [11] reported in this volume underscored the favorable advantage of mixing biochar with manure-based compost on enhancing the shoot and root biomass and nutritional uptake of corn grown in mine soils with heavy metal contaminations. The greatest total corn biomass was from soils treated with manure-based biochars (i.e., poultry litter, beef cattle manure) and the least total biomass was from wood-based biochar (lodge pole pine). The results of their study show that the incorporation of biochar enhanced the phytostabilization of Cd and Zn with concentrations of water-soluble Cd and Zn lowest in soils amended with manure-based biochars while improving the biomass productivity of corn. They concluded that the phytostabilization technique, when combined with the biochar and manure-based compost application, has the potential for remediation of heavy metals-polluted soils.

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