

### What is the difference between a digester and a co-digester?

- On-farm digesters typically only take manure (manure-only digesters), but can also be used as a “catch-all” term for both types of digesters.
- On-farm co-digesters mix manure with a number of inputs from outside the farm including food waste (which can include various types of industrial food manufacturing waste), yard waste, and biosolids (human sewage).
- Dr. Mark Borchardt, USDA Agricultural Research Service: “Digesters are designed to maximize methane production. It's not like wastewater treatment plants for human waste...it's just two different goals.”<sup>2</sup>

### What is digestate?

Digesters create waste called digestate. Operators typically separate digestate into solid and liquid forms using a “screw press.” Most of the phosphorus is shifted into the dry portion and the nitrogen is shifted into the liquid portion.<sup>3</sup>

- Dry digestate: spread on fields as fertilizer or used for animal bedding
- Liquid digestate: spread on fields as fertilizer or used for irrigation

### How can digestate and biogas production negatively impact the water, soil, and air in my community?

#### *Water Contamination*

- “Both phosphorus and nitrate are abundant in manure, and digesters are often pitched as a way to curb nutrient pollution. This is overselling it, said Rebecca Larson, a professor of biological systems engineering at the University of Wisconsin-Madison. ‘It’s just a misconception that was pushed a long time ago,’ she said. ‘I’m not sure where it really started.’...at the end of the day, a phosphorous atom goes in and a phosphorous atom comes out. Manure digesters don’t get rid of these nutrients, full stop.”<sup>4</sup>
  - Applying digestate to fields can increase the risk of algal blooms and eutrophication, particularly if the digestate is applied to fields that already have high levels of phosphorus.<sup>5</sup>
- **Nitrogen-** “Much of the nitrogen in raw manure is converted from its organic form to ammonium. Ammonium can be transformed to either ammonia or nitrate... Nitrate can be leached through the soil and may eventually reach groundwater. Field application and management to reduce nitrogen losses may be more demanding for digester effluent than for untreated liquid manure.”<sup>6</sup>
  - This means that nitrate pollution in groundwater can be more of a problem with digestate because it becomes more water soluble.
    - Consuming nitrate in drinking water may increase the risk of pregnancy complications, blue baby syndrome, thyroid disease, as well as breast, colorectal, and bladder cancer.<sup>7</sup>
- **Pathogens-** Digesters reduce some, but not all of pathogens.
  - After the completion of the digestion process, researchers in Wisconsin found “nearly every microbe we could detect” in the liquid digestate.<sup>8</sup>

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<sup>1</sup> For any questions or inquiries related to this fact sheet, please contact Dr. Sarah D’Onofrio at sarah.e.donofrio@gmail.com

<sup>2</sup> Gordon, Scott. 2023. “What Manure Digesters Can And Can’t Do.” <https://wiscontext.org/what-manure-digesters-can-and-cant-do>

<sup>3</sup> Penn State Extension. 2023a. <https://extension.psu.edu/fate-of-nutrients-and-pathogens-during-anaerobic-digestion-of-dairy-manure>

<sup>4</sup> Gordon, Scott. 2023. “What Manure Digesters Can And Can’t Do.” <https://wiscontext.org/what-manure-digesters-can-and-cant-do>

<sup>5</sup> Horta, Carmo, and João Paulo Carneiro. 2021. “Phosphorus Losses to Surface Runoff Waters After Application of Digestate to a Soil Over Fertilised with Phosphorus.” *Water, Air, & Soil Pollution* 232(10):439. doi: 10.1007/s11270-021-05382-y.

<sup>6</sup> Penn State Extension. 2023b. <https://extension.psu.edu/anaerobic-digestion-biogas-production-and-odor-reduction>

<sup>7</sup> Ward, Mary H., et al. 2018. “Drinking water nitrate and human health: an updated review.” *International journal of environmental research and public health* 15.7: 1557. doi: 10.3390/ijerph15071557

<sup>8</sup> Burch, Tucker R., et al. 2022. “Fate and Seasonality of Antimicrobial Resistance Genes during Full-Scale Anaerobic Digestion of Cattle Manure across Seven Livestock Production Facilities.” *Journal of Environmental Quality* 51(3):352–63. doi: 10.1002/jeq2.20350.

- “Cryptosporidium parvum, Salmonella spp., norovirus, Streptococcus pyogenes, E. coli enteropathogenic (EPEC), Mycobacterium spp., Salmonella Typhi (followed by S. paratyphi), Clostridium Spp., Listeria monocytogenes and Campylobacter coli were found to be the most relevant (top 10) pathogens in relation to potential risk from spreading anaerobic digestate on agricultural land, specifically in Ireland.”<sup>9</sup>

### *Soil Contamination*

- According to the National Organic Standards Board (NOSB), digestate is too toxic to be used in organic production because of high levels of heavy metals, pathogens, and unknown effects on human health.<sup>10</sup>
- Microplastics- plastics in food packaging leach into the food waste itself and bioaccumulate in soils.<sup>11</sup>
  - “Food itself is also a source of microplastic particles...Plastic contamination rates in purely food waste streams may be higher, as available evidence indicates plastic contamination levels in food waste streams may be higher than that of other organics waste streams, such as yard waste.”
  - “Due to their highly stable chemical structure, most conventional petroleum-based plastics are resistant to total degradation and may persist in the environment for centuries (Ali et al., 2021). Through time, plastics may accumulate in soils (Y. Yu & Flury, 2021), with macroplastics fragmenting into microplastics or even nanoplastics due to physicochemical and biological degradation (Ali et al., 2021). This partial degradation can release additives and impurities that may be harmful to human and ecosystem health (Rillig et al., 2021).”
- PFAS- found in food packaging, cookware, and food processing equipment and transfer to food waste
  - “PFAS are extremely persistent in the environment, and they are generally more water-soluble than other persistent organic pollutants...PFAS cause widespread contamination in soils and groundwater and can be found even in rural regions, far from potential PFAS sources (Brusseau et al., 2020).”<sup>12</sup>

### *Toxic Air Pollution*

- Volatile organic compounds (VOCs)-Zheng et al. (2019) detected 49 different types of VOCs. Almost a third (32.77%) of the VOCs emitted from digestate were hazardous to human health: 8 of the compounds were carcinogenic and 14 were known to cause organ damage in humans.
- Ammonia- Holly et al. (2017) found in their study of digestate in Wisconsin that in storage, ammonia emissions increased 81%.<sup>13</sup>
  - “The most frequently reported health complaints from [ammonia] exposure include eye, nose, and throat irritation, headache, nausea, diarrhea, hoarseness, sore throat, cough, chest tightness, nasal congestion, palpitations, shortness of breath, stress, drowsiness, and alterations in mood (Schiffman and Williams, 2005; Wing and Wolf, 2000).”<sup>14</sup>
  - When ammonia combines with sulfur dioxide, a pollutant from the biofuel production process, it can create fine particulate matter (PM2.5)- the leading cause of air pollution deaths from agricultural production.<sup>15</sup>

<sup>9</sup> Nag, Rajat et al. 2020. “Ranking hazards pertaining to human health concerns from land application of anaerobic digestate.” *Science of the Total Environment* 710: 136297. doi: 10.1016/j.scitotenv.2019.136297.

<sup>10</sup> National Organic Standards Board. 2017. Updated in 2023. <https://www.ams.usda.gov/sites/default/files/media/CSAnaerobicDigestateFinalRec.pdf>

<sup>11</sup> EPA. 2021. Emerging Issues in Food Waste Management: Plastic Contamination.

<sup>12</sup> O’Connor, James, et al. 2022. “Physical, chemical, and microbial contaminants in food waste management for soil application: a review.” *Environmental Pollution* 300: 118860. <https://doi.org/10.1016/j.envpol.2022.118860>

<sup>13</sup> Holly, Michael A., et al. 2017. “Greenhouse Gas and Ammonia Emissions from Digested and Separated Dairy Manure during Storage and after Land Application.” *Agriculture, Ecosystems & Environment* 239:410–19. doi: 10.1016/j.agee.2017.02.007.

<sup>14</sup> Wyer, Katie E., et al. 2022. “Ammonia emissions from agriculture and their contribution to fine particulate matter: A review of implications for human health.” *Journal of Environmental Management* 323: 116285.

<sup>15</sup> Domingo, Nina G. G., Srinidhi Balasubramanian, Sumil K. Thakrar, Michael A. Clark, Peter J. Adams, Julian D. Marshall, Nicholas Z. Muller, Spyros N. Pandis, Stephen Polasky, Allen L. Robinson, Christopher W. Tessum, David Tilman, Peter Tschofen, and Jason D. Hill. 2021. “Air Quality–Related Health Damages of Food.” *Proceedings of the National Academy of Sciences* 118(20):e2013637118. doi: 10.1073/pnas.2013637118.