CAFOs, Biogas Plants, Environmental Justice, and Health Impacts in North Carolina

COMMUNITY ENGAGEMENT, ENVIRONMENTAL JUSTICE, & HEALTH

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CAFO Process

- Currently, most swine concentrated animal feeding operations (CAFOs) in the United States collect the waste produced by their animals with scrapers, flushing systems, or gravity flow gutters, and then store the wet livestock manure in **vast open-air pits**.
- Producers use a variety of **lagoon systems for liquid manure,** including **anaerobic lagoons, aerobic lagoons, and temporary storage bins**. These lagoons have a size as great as six to seven-and-a-half acres and can contain as much as **20 to 45 million gallons of wastewater.** In North Carolina, a facility of 2,500 swine may generate **26 million gallons of lagoon liquid,** close to one million gallons of lagoon sludge, and 21 million gallons of slurry. [16]

Average Swine Waste Generated Annually by Different Types of North Carolina Facilities with 2,500 Swine[i]

Production Unit[ii]	Animal Unit	Animal Unit Equivalent Live Weight (pounds)	Lagoon Liquid[i] (gallons per animal unit/year)	Lagoon Sludge[iv] (gallons per animal unit/year)	Slurry[v] (gallons per animal unit/year)
Feeder-to finish	Per head capacity	135	2,317,500	82,500	1,877,500
Farrow-to weanling	Per active sow	433	8,007,500	195,000	6,595,000
Farrow-to feeder	Per active sow	522	9,652,500	235,000	7,950,000
Farrow-to finish	Per active sow	1,417	26,202,500	955,000	21,585,000

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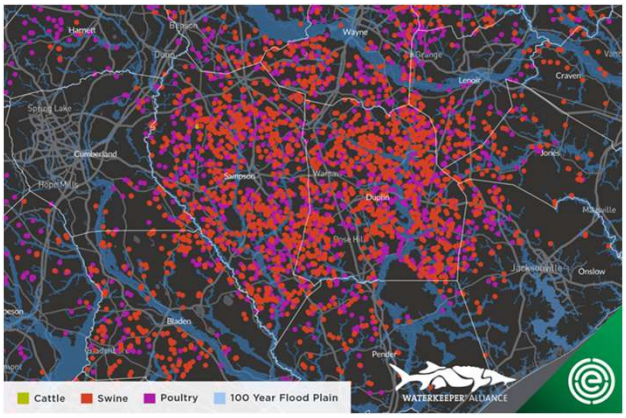
Environmental Racism and CAFOs

From Southern Environmental Law Center on biogas in NC:

- **Environmental racism:** "Native Americans, African Americans, and Latinx Americans are 2.18, 1.54, and 1.39 times more likely than whites to live within three miles of industrial hog operations, respectively." [5]
- NC's biogas production "...**relies on an outdated waste management system** that involves storing untreated hog manure and urine in uncovered pits where the solid waste falls to the bottom and the liquid waste rises to the top. The liquid waste is then sprayed onto cropland. This waste management system is called the **lagoon and sprayfield system**." [5]



Concentrated animal feeding operations in Eastern North Carolina

https://e360.yale.edu/features/turning-hog-waste-into-biogas-green-solution-or-greenwashing

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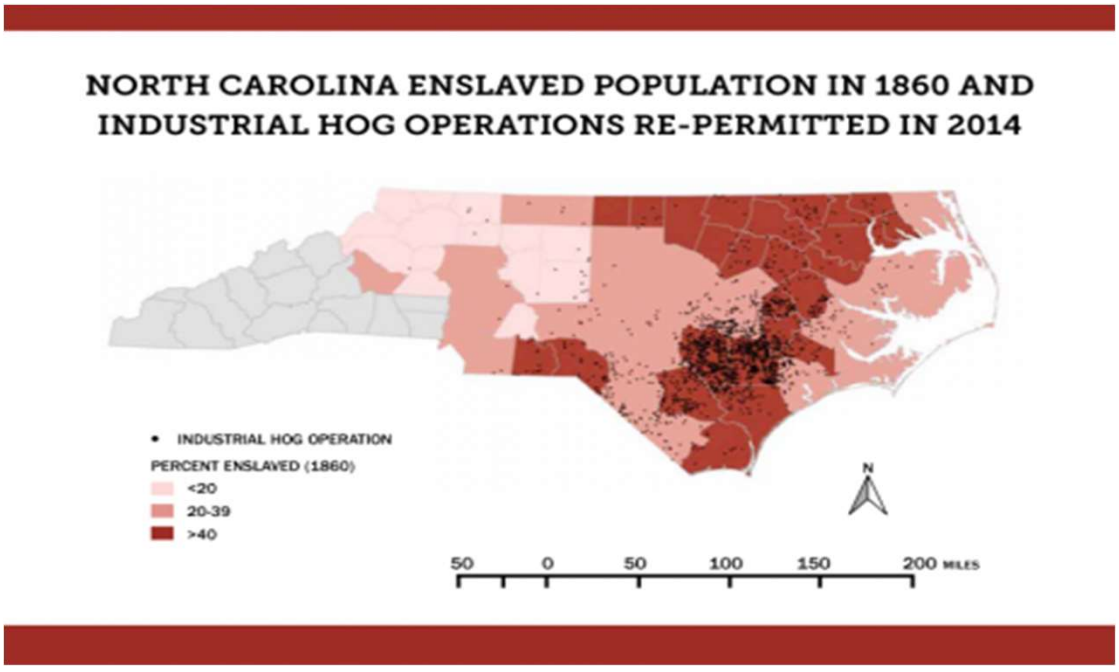

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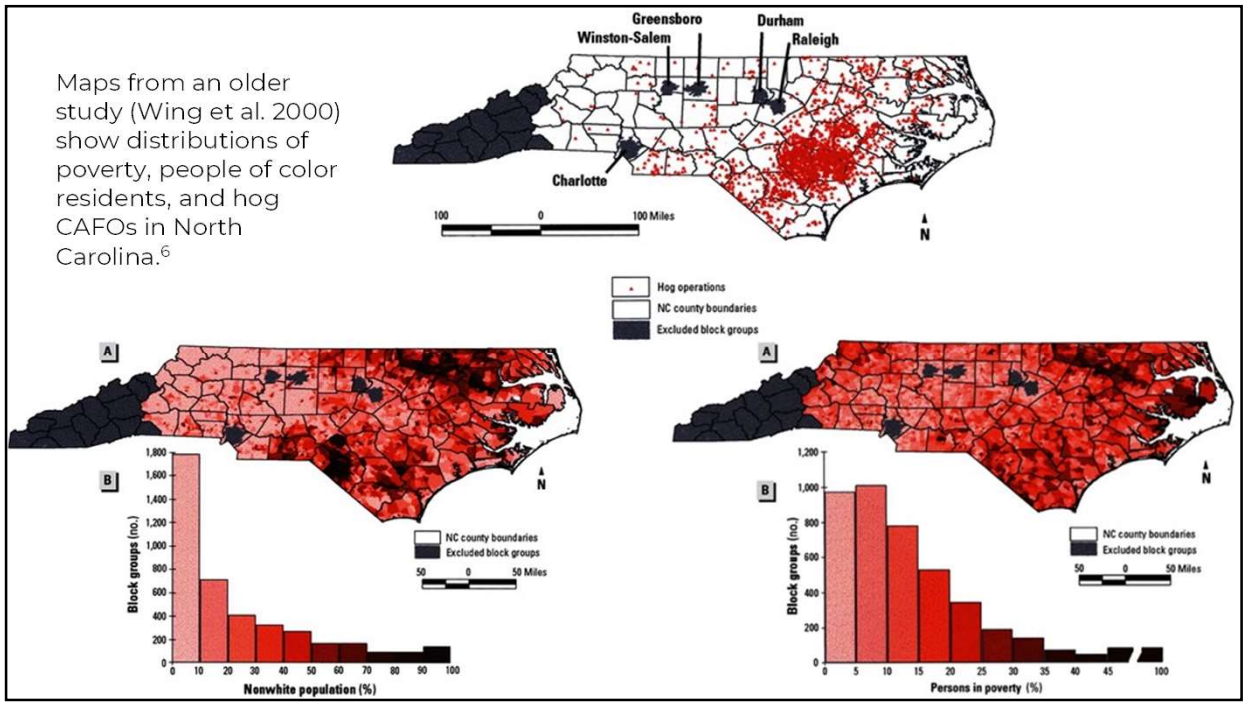
Maps from an older study (Wing et al. 2000) show distributions of poverty, people of color residents, and hog CAFOs in North Carolina.[6]



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Why are hog CAFOs an Issue?

- Confinement building, lagoon and sprayfields
- Exposure to microbes through the air, well water, and surface water
- Release H_2S, NH_3, NOx, SOx, PM, and VOCs

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Environmental Impacts of CAFOs

- Nutrient runoff (ammonia, nitrates, and phosphorus) and deposition to waterways and terrestrial ecosystems
- Runoff leads to eutrophication, algae growth, and fish kills
- Microbial contaminants in surface and groundwater
  - *E. coli serotypes*
  - Salmonella
  - Giardia
  - Cryptosporidium
  - Use of antimicrobials produces antibiotic resistant microbes (Shea, 2004)
    - **Methicillin-resistant Staphylococcus aureus** (**MRSA**)

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Swine CAFOs…Waste Associated Contaminants

Nutrients

- Wastes also contain high quantities of many nutrients such as nitrogen and phosphorus.
- In public health the most notable of these nutrients is nitrogen.
  - Excessive nitrates in water continue to be a cause of methemoglobinemia (blue-baby syndrome)-an underrecognized cause of illness and death in infants. Some evidence suggests that methemoglobinemia is more likely when nitrate-containing water is also contaminated with bacterial species (as might be expected when groundwater is contaminated with fecal wastes), because the bacteria convert the nitrate to nitrite, causing diarrhea in infants.
- In addition, animal studies and some human studies suggest that reproductive health effects such as central nervous system developmental defects and miscarriages may occur with excessive intake of nitrates.

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Exposure to CAFO Pollutants and Health

- Releases of H2S and NH3 from hog CAFOs may cause health problems.
- NH3, a strongly alkaline, colorless and water-soluble vapor with its characteristically pungent odor (detectable from 1-5 ppm) can create respiratory hazards.
- Exposure to H2S may produce symptoms such as headache, eye irritation, small-airway obstruction and neurological dysfunction.
- Children may be particularly susceptible because they receive a higher concentration (dose per body weight) than adults.
- H2S levels on property adjacent to CAFOs has exceeded WHO guidelines. A 1-hr time-weighted average of 150 ppb at the residential level and 70 ppb at the property line of the CAFO for both pollutants have been recommended.
- Other pollutants including VOCs, PM2.5, endotoxins and bioaerosols may also pose human health concerns for exposed rural populations and lead to health disparities.

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Impacts on Human Health

A hog farm in Farmville, North Carolina.
https://e360.yale.edu/features/turning-hog-waste-into-biogas-green-solution-or-greenwashing

- A study conducted by the Environmental Health Scholars program at Duke University School of Medicine found that **communities located near hog CAFOs** had **higher overall rates of infant mortality** & **mortality due to anemia**, **kidney disease**, **tuberculosis**, & **septicemia**. [7]
  - The communities also had **higher hospital admissions**, **ER visits**, & **low-birthweight infants**.
- More increased health risks from living near hog farms & CAFOs: [4, 5]
  - **Respiratory** issues
  - Decline in **quality of life** (ei. presence of noxious gases)
  - **Irritation** to **eyes**, **noses**, & **throats**
  - Possible **mental health disorders** (anxiety, depression, mood disorders)
- High levels of **nitrous oxide**: **respiratory** issues & reduced lung function, **headaches**, eye **irritation**, loss of **appetite**, **corroded teeth** [4]
- Measures of **odor, endotoxin, hydrogen sulfide, and PM10** associated with increased respiratory difficulty, sore throat, chest tightness, nausea, and eye irritation
- **Hydrogen sulfide** and **semivolatile particles** linked to reports of feeling stressed, annoyed, nervous, and anxious [6]

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Epidemiology Studies

- Correlation between proximity to CAFO and health effects (Thu et al 1997; Wing and Wolf 2000, Schiffman et al 1995)
  - Coughing, headaches, burning of eyes, nose and throat, nausea, vomiting, fatigue, anger and depression
  - Similar to heath effects observed in swine CAFO workers (Donham 1989, 1991)
- Exposure to CAFO gases leads to adverse mental health outcomes found by (Bullers 2005; Schiffman et al 2005; 1995) using POMS
- Mirabelli et al (2006) and Merchant et al (2005) found a high prevalence of asthma in exposed children
- CAFO odors have an immunosuppressive effect (Avery et al 2004)

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Passive Sampling in NC

- NH3 was collected using passive diffusion tubes in triplicate set at a site for one week at a time. Sampling occurred from October 2003 to May 2004 (twenty sites) and from July 2004 to October 2004 (twenty-three sites) at varying distances from hog CAFOs near homes and schools.
- Figures 2a and 2b display the location of sampling sites for Phase I and II, respectively. During Phase I, NH3 sampling sites were located in Nash, Edgecombe, and Wilson (low emission density counties) and Greene (a high emission density county).
- Phase I sampling was performed to assess the spatial gradient of exposure across a region of varying emission density.
- During Phase II, sites were located in Greene, Lenoir, Sampson, and Duplin, all high emission counties.
- Phase II sampling measured NH3 levels where populations are exposed to high levels of pollution and during the summer when levels are expected to be at their highest due to warmer temperatures.

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Passive Sampling Locations in NC

Fig 2a. Location of Phase I Sampling Sites

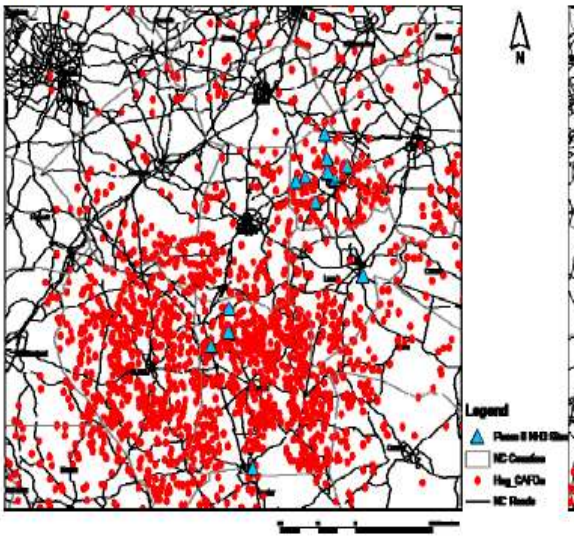
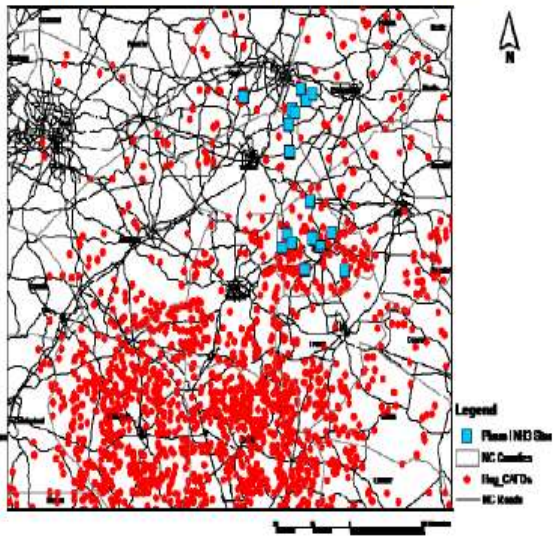


Fig 2b. Location of Phase II Sampling Sites



Wilson and Serre 2007a,b

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Passive Sampling Results

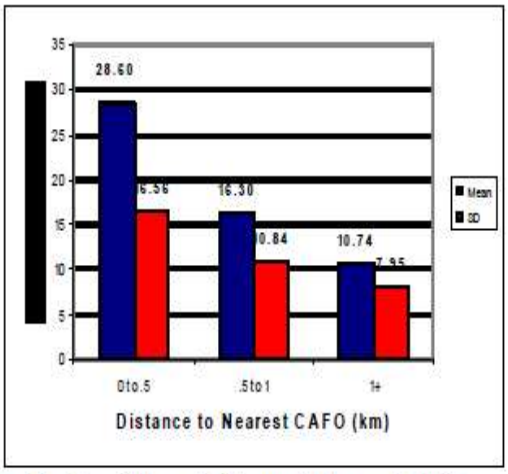

Fig 3a. Mean NH_3 and Distance to Nearest CAFO (Phase I sampling)

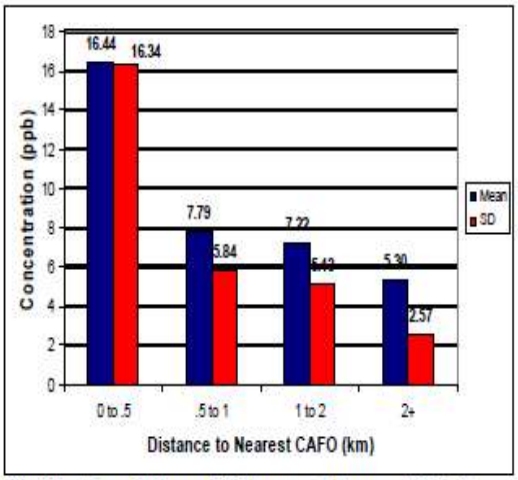

Fig 3b. Mean NH_3 and Distance to Nearest CAFO (Phase II Sampling)

Wilson and Serre 2007a,b

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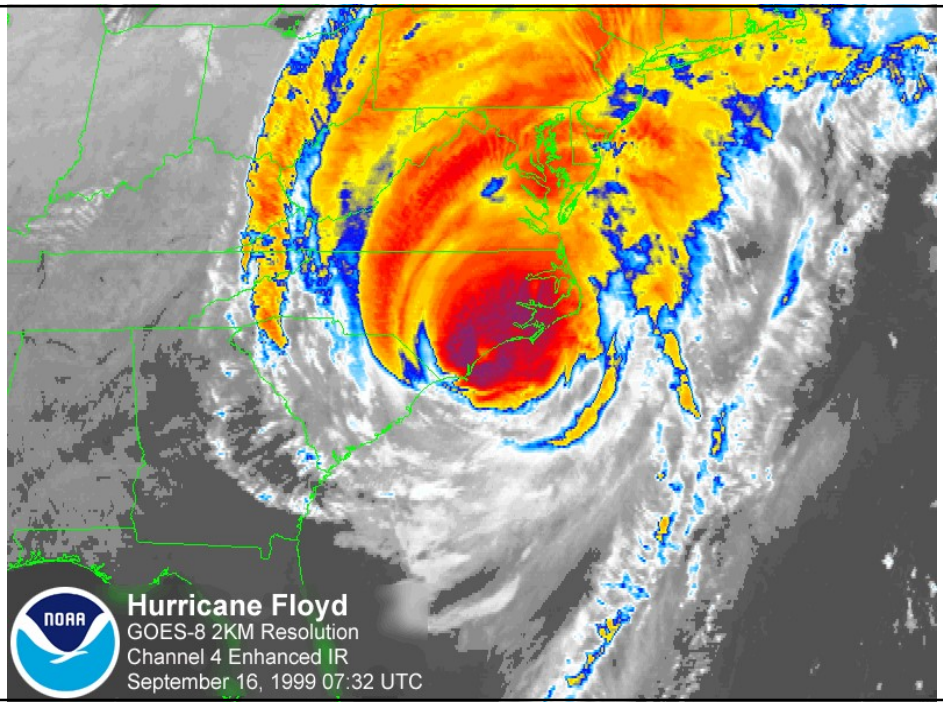

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Hurricane Floyd (1999)

- 100,000 dead hogs
- 500,000 dead turkey
- 2.4 million dead chickens

**Reported

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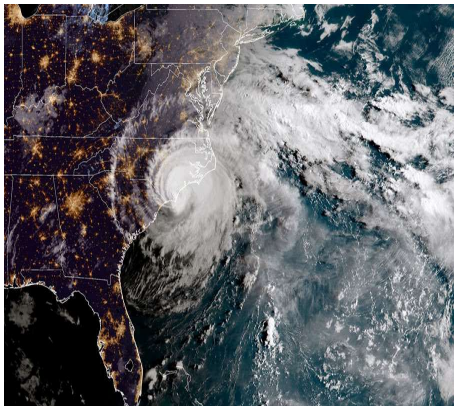
Hurricane Florence (2018)



NOAA via Getty

Flooded Chicken Farm- Steve Helber/AP

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Biogas Process

- Biogas is created by covering a large, unlined hog waste lagoon and trapping the methane that comes off the waste in the lagoon. Methane can be processed and used to generate electricity on-site.
- Methane can also be transported through pipelines, processed at a central facility, and injected into a natural gas pipeline. This type of project is called a directed biogas project. Directed biogas projects cause more pollution than projects that develop biogas for on-site electricity use.
- The accumulation of gases formed in the process of breaking down animal waste is toxic, oxygen consuming, and potentially explosive, and farm workers exposure to lagoon gases has even caused deaths
- The emissions are the result of the decomposition of liquid manure by anaerobic bacteria during storage and treatment. This process releases 400 volatile organic compounds, including hydrogen sulfide, ammonia, dusts, endotoxins, and methane [16]

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Background on Biogas Plants

- "Biogas" is produced when **bacteria break down organic materials** *(food waste, animal waste, plants)* through **anaerobic digestion** → the product is **gas** for energy, some solid and liquid materials, & harmful **byproducts** *(ie. NOx, hydrogen sulfide, ammonia)*
- Biogas requires **fossil fuel infrastructure**, many of which **leak methane**: truck fleets, pipelines, connections to the power grid, existing gas industry factories [4]
- **Greenwashing** & **legalized pollution** [4]
  - Biogas plants are falsely advertised as a renewable & "green" energy solution to pollution from fossil fuels & industrial agriculture, like Concentrated Animal Feeding Operations (CAFOs)
  - Manure-digesters aka manure-to-energy projects are marketed to farmers as way of decreasing costs of production (animal manure → revenue stream), but they're expensive and often require farmers to produce more waste to meet the needs of the digester
- **Farm Act of 2021 advances the building of biogas plants**, including plans by Smithfield Food Inc. and Dominion Energy Inc. in NC to build 30 miles of pipeline across areas in eastern NC, like Sampson & Duplin counties, to transport biogas from hog farms [10]

Refinery in Kenansville converts gas from the Optima KV project in Duplin County that pipes in methane gas from hog farms. The gas is used to produce electricity at Duke Energy's Smith Energy Complex in Richmond county.

https://www.northcarolinahealthnews.org/2019/01/04/smithfields-plans-to-cover-hog-lagoons-could-spur-n-c-biogas-industry/

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Impacts on Water Quality

- Used to produce biogas, waste from factory farms is held in **lagoons**, **spray fields**, and **other waste collection sites**
- These collection sites **overflow** and **leak** and **contaminate ground** and **surface water**
- **Nitrogen** from the unlined pits seeps into waterways and contributes to groundwater and well pollution, increasing the frequency and intensity of **algal blooms** and fish kills [7]
- Waste from factory farms contain **antibiotics**, **hormones**, **pathogens**, **heavy metals**, other **chemicals** [4]
- Capping lagoons leads to higher concentration of **ammonia** in the waste [7]
- Liquid waste is sprayed onto fields next to the industrial hog operations, then **runs off** into **rivers** and **streams**, **seeps** into the **groundwater** [7]

Waste lagoon at a hog farm in Eastern North Carolina

https://www.nytimes.com/2018/09/19/climate/florence-hog-farms.html

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Impacts on Air Quality

"When manure-to-energy projects are installed on factory farms, the **processing of the methane produced for the power grid** or for the **transportation sector releases CO2** and **hazardous air pollutants**, and requires the installation of **gas pipelines** and other infrastructure that **leak** tremendous volumes of **methane**." [4]

- **Methane**
  - The methane and nitrous oxide emitted from manure management activities account for 16% of total US agricultural emissions
  - Atmospheric concentrations of methane are >2.5 times above pre industrial levels
  - As a potent GHG, methane amplifies climate change
- **Noxious gases** → released from CAFO ventilation systems
- **More air pollutants: NOx**, **hydrogen sulfide**, **gaseous ammonia**

Methane accumulates under a cover at a hog waste lagoon (anaerobic digestion).
https://www.npr.org/sections/thesalt/2018/04/17/601857456/in-north-carolina-hog-waste-is-becoming-a-streamlined-fuel-source

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Impacts on Soil Quality

Hog waste sprayed onto sprayfields In Warsaw, North Carolina, posing contamination risks to soil in the area.
https://ehp.niehs.nih.gov/doi/full/10.1289/ehp.121-a182 and 2013 Donn Young Photography

- Biogas technologies risk **nutrient contamination**
- **Long-term biogas operations accumulate heavy metals in topsoil and plants** → leads to environmental & human health harm
- **Contaminated soils** pose **health & cancer risks to farmers** [8]
- **Some lagoons & older pits are are unlined** → no protective layer to protect the soil & groundwater from the waste, usually hard clay is the separator
- **Heavy rains & severe weather events** → lagoons can overflow → **wastewater seeps into soil** & groundwater [9]
  - This wastewater can contain nitrates that have been linked to increased miscarriages, infant mortality, and blue baby syndrome

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Potential Issues with Antibiotics

- **Antibiotics applied to livestock**, as well as their partially still active metabolites, were **detected in the excrements of treated animals** in several studies
- In multiple studies, **pig manure** was reported as a **reservoir of bacteria carrying antibiotic resistance genes** (ARGs) and **genes conferring resistance** to all major classes of antibiotics have been detected in DNA of pig manures and slurries
- When **spreading manure on field soils**, **ARGs** located might be **transferred to soil bacteria**, contributing to the **spread of antibiotic resistance in agricultural settings** [15]
- **Long-term application of biogas slurry and residue** that were contaminated with antibiotics **increased the number of ARGs in soil** and increased the **number of antibiotic resistant bacteria** [14]

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Paths Forward

NC residents protesting the environmental injustices and health harms of living near CAFOs.
https://waterkeeper.org/news/deq-report-shows-n-c-must-do-more-to-protect-communities-near-industrial-hog-operations/

"Ultimately, biomethane is a false solution that perpetuates the expansion of big ag monopolies, the toxic, hazardous, and destructive practices of CAFOs and fossil fuel infrastructure." [4]

- **Organize** & **advocate** for policies that **invest** in **farmers** and **underserved communities** (instead of the fossil fuel industry), **cleanup pollution**, increase **transparency** (especially in the food and energy sectors), **strengthen public health** regulations, and build **solutions** from **community input** [9, 4]
- **Oppose** increases in **fossil fuel infrastructure** and **incentives to advance biogas**
- **Be vocal** about the **harms of biogas** and how it's not green or a renewable energy
- **Transitioning away from CAFOs** and **industrial agriculture** toward **food systems** based in **community** & **indigenous knowledge**, **reciprocity**, and **environmental justice**

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Thank you!

COMMUNITY ENGAGEMENT, ENVIRONMENTAL JUSTICE, & HEALTH

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