

# Chapter 10

## Conclusion

It is clear that current confined animal feeding operation (CAFO) manure management methods are not sustainable. Even with new federal and state environmental protection regulations and permits, CAFOs continue to concentrate and mismanage manure, and rural communities and their lakes, rivers, and streams pay the price.

A dramatic shift towards a more sustainable agriculture is necessary and inevitable. A secure future for rural America depends on developing technologies that reduce potentially harmful impacts of manure storage and land application while still allowing farms to benefit from the value of manure. Reducing the negative environmental impacts of CAFOs and improper manure management, regardless of farm size, preserves soil fertility and health, improves water quality, and reduces odors. This challenge may partially be met through the implementation of the technologies described in this report. When executed properly as part of a comprehensive nutrient management plan, these technologies have the potential to reduce the flow of pollutants that are devastating rural watersheds.

A move towards sustainable agriculture and appropriate manure management depends on the actions of farmers, policy makers, consumers, and local residents alike. A critical element in the future of agriculture is informed public participation. Local residents, taking part in public hearings, dialogues, and casual conversations, should rightfully control the destiny of their communities. Their ability to present local officials and fellow residents with detailed comments is vital to meaningful public hearings over the approval of individual

CAFO or the more general debate about the appropriate direction of agriculture. This Waterkeeper Alliance report should be considered a resource for local citizens taking part in this important process.

# Glossary of Terms

**Acetogenesis:** The formation of acetic acid from carbon dioxide and hydrogen.

**Acidogenesis:** The formation of propionic and butyric acids from glucose.

**Acid rain:** Any form of precipitation with a pH less than 5.6, the normal pH of rain. Nitrogen oxides ( $\text{NO}_x$ ) and sulfur dioxide ( $\text{SO}_2$ ) released into the atmosphere, generally by anthropogenic sources, turn into acids, lowering the pH of precipitation. Acid rain is harmful to vegetation, soils, and waterbodies.

**Actinomycetes:** Specialized bacteria with branching cell chains called filaments that have a superficial resemblance to fungi and a hunger for tough, raw tissues in manure.

**Aerobic:** An oxygenated environment or requiring an oxygenated environment to survive.

**Airshed:** A geographical area sharing the same air.

**Amendments:** Organic material added to the manure to change bulk weight, moisture content, carbon content, and porosity. Examples of amendments are sawdust, straw, recycled compost, rice hulls, cured compost, and peanut hulls. Amendments are chosen based on cost, availability, and degradable carbon content; they become part of the finished product.

**Ammonia volatilization:** A process in which gaseous nitrogen-ammonia is released into the atmosphere.

**Anaerobic:** An oxygen-free environment or requiring an oxygen-free environment to survive.

**Anoxic:** Lacking oxygen.

**Autotrophic:** Organisms that make their own food by using either solar or chemical energy. The bacteria responsible for nitrification use the chemical energy released during ammonia oxidation to make their food.

**Biochemical oxygen demand (BOD):** A measure of the amount of oxygen needed by aerobic microorganisms to break down solids and organic matter present in wastewater. Although BOD is not a specific compound, it is defined as a conventional pollutant under the federal Clean Water Act. The  $\text{BOD}_5$  test is a five-day laboratory test to determine the amount of oxygen available for biochemical oxidation in a sample.

**Biodegradable:** A material that can be broken down by biological processes.

**Biodiversity:** The diversity of plant and animal species in an ecosystem.

**Biogas:** A combustible gas produced during the anaerobic decomposition of organic material. Biogas is primarily composed of methane, carbon dioxide, and hydrogen sulfide.

**Biomass:** The total dry mass of an individual or population.

**Bonded liquid:** Liquid physically or chemically bound to solid particles.

**BTU:** British Thermal Units; a measure of energy; the amount of heat required to raise the temperature of one pound or one pint of water one degree Fahrenheit. One BTU is roughly equivalent to 1055 Joules or 252 calories.

**Bulk density:** Weight per unit volume.

**Bulking agent:** Organic or inorganic material used to provide structural support and to increase the porosity of the mixture for effective aeration. Wood chips are one of the most common bulking agents, although recoverable agents such as shredded tires are also gaining in popularity. Bulking agents are usually screened from the finished compost and can be reused.

**Capillary action:** The movement of a liquid through small spaces in a porous medium by the forces of adhesion, cohesion, and surface tension.

**Chemical oxygen demand (COD):** A measure of the oxygen-consuming capacity of inorganic and organic matter present in wastewater. COD may be higher than BOD because the chemical oxidant may react with substances that bacteria do not consume.

**Clarifier:** A physical unit designed to settle and remove biosolids from wastewater.

**Cogeneration:** The simultaneous production of electric energy and thermal energy.

**Curing stage:** The final stage in composting where the microbial population shifts from bacteria to fungi and actinomycetes, which can break down the less degradable organic matter like chitin, cellulose, and lignin.

**Decant:** To draw off the upper layer of liquid after denser materials have settled to the bottom.

**Denitrification:** The conversion of nitrate to dinitrogen gas by heterotrophic facultative bacteria.

***E. coli:*** *Escherichia coli*; a type of bacteria found in the digestive tracts of all mammals and sometimes used as an indicator organism to determine if pathogens are present. *E. coli* OH:157 is a pathogenic strain of the bacteria.

**Electron acceptor:** A substance that accepts electrons and is reduced during an oxidation-reduction reaction. Examples of electron acceptors used by bacteria are oxygen (aerobes), nitrate (nitrate reducing bacteria), and sulfate (sulfate reducers).

**Emulsion:** A mixture of two liquids that do not form a true solution, but are instead held together by a surfactant, keeping droplets of one liquid dispersed throughout the other.

**Eutrophication:** A process where a water body becomes nutrient-enriched and eventually unable to sustain plant and animal life.

**Evapotranspiration:** The sum of the evaporation of water from the earth's surface and transpiration, the evaporation of water from plant leaves and other plant surfaces.

**Exothermic:** A process that gives off heat.

**Facultative:** An environment that contains both oxygenated and oxygen-free regions or microorganisms that can live in both oxygenated and oxygen-free environments. When oxygen is not available, these organisms can switch from respiration to fermentation.

**Fecal coliform:** A group of bacteria in the family *Enterobacteriaceae* and commonly found in the digestive tracts of all mammals. The presence of fecal coliform in water may indicate fecal contamination and the existence of pathogens.

**Fertigation:** The irrigation of nutrient-rich water for fertilizer using irrigation equipment.

**Flare:** A method of burning biogas to prevent explosive gases from accumulating or entering the atmosphere.

**Floatable bedding:** Any type of bedding that will float or stay in suspension, including wood shavings and grain hulls.

**Flocculant:** A substance added to a solution to help particles bind together.

**Freeboard:** The vertical space between the surface of a water body and the top of the surrounding embankment.

**Free liquid:** Liquid that is not bound to solid particles.

**Greenhouse gas:** A gas that captures heat emitted from the earth, contributing to global climate change.

**Helminth:** An intestinal parasitic worm.

**Heterotrophic:** Organisms that cannot make their own food and must obtain energy by consuming other organisms or their organic products; a consumer or a decomposer in the food chain.

**Hopper:** A funnel-shaped receptacle that moves the manure via gravity to storage or treatment units.

**Humus:** Decomposed organic matter.

**Hydraulic retention time (HRT):** The amount of time that a substance is retained in a reactor, representing the time required to treat the substance.

- Hydric soils:** Soils that are flooded or saturated long enough to develop anaerobic conditions that favor the growth of hydrophytic (water-loving) plants.
- Hydrogen sulfide:** A colorless, flammable, toxic ( $H_2S$ ) gas that smells like rotten eggs, produced during the decomposition of organic matter.
- Hydrolysis:** The decomposition of a compound by reaction with water.
- Indoles:** A group of volatile compounds consisting of fatty acids. Indoles are produced during the decomposition of organic matter.
- Inert:** A material or compound that does not chemically react with other elements.
- kWh:** Kilowatt-hours, a measure of energy. One kWh is roughly equivalent to 3,600,000 Joules or 3.6 Megajoules.
- Lagoon:** A shallow pond where sunlight, oxygen, and bacteria degrade and transform compounds in manure.
- Larvae:** (*pl.* of larva) Insects that are in the immature, worm-like stage after hatching from the egg.
- LP gas:** Liquefied petroleum gas; a family of light hydrocarbons called "gas liquids" comprised mostly of propane ( $C_3H_8$ ) and butane ( $C_4H_{10}$ ). LP gas is derived from natural gas processing and crude oil refining and can liquefy under modest pressure and cooling for easy storage and transportation.
- Luxury microbial uptake:** A process where microorganisms digest and incorporate more phosphorus than they physiologically require. This remains a highly researched, yet poorly understood process.
- Macronutrient:** An element required in relatively large amounts for growth and reproduction; nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and sulfur (S).
- Macropore:** Large opening in unsaturated soils formed by the shrinking and cracking of soils, plant roots, soil fauna, or by tillage operations. The presence of macropores may encourage preferential flow of water and contaminants to groundwater.
- Manure gases:** Volatile compounds released from animal manure. Many cause problems ranging from offensive odors to adverse human health and environmental impacts.
- Mercaptans:** A group of volatile compounds formed from carbon, hydrogen and sulfur. Mercaptans produce a very offensive odor.
- Methane:** A gas ( $CH_4$ ) produced when anaerobic bacteria decompose organic matter. Methane is a strong greenhouse gas. Methane can be used as fuel.
- Methanogens:** Bacteria that produce methane gas by combining acetic acid, hydrogen gas, and carbon dioxide.

- Methemoglobinemia:** Also known as "blue baby syndrome"; a condition where nitrate is converted to nitrite in the body. The nitrite interferes with the blood hemoglobin's ability to carry oxygen, which can cause tissues to become blue in color. This condition may be fatal if untreated.
- MPN:** Most Probable Number, a unit used to quantify the results from certain microorganism counts.
- Natural gas:** A naturally occurring mixture of hydrocarbons, principally methane, and non-hydrocarbons; found in porous geological formations, often in association with crude oil. Natural gas is the cleanest burning fossil fuel.
- Nitrification:** The conversion of ammonia to nitrite and then to nitrate by the autotrophic aerobic bacteria *Nitrosomonas* and *Nitrobacter*, respectively.
- Nutria:** A large semi-aquatic rodent native to South America but invasive in the United States.
- Obligate:** Microorganisms that can only exist in oxygen-free environments.
- Orthophosphate:** Inorganic phosphate.
- Pathogen:** A disease-causing organism.
- Phenols:** A group of volatile compounds formed by a hydroxyl group (OH) attached to a benzene ring. Phenols are produced during the decomposition of organic matter.
- Phosphorus accumulating organisms (PAOs):** Microorganisms with the ability to store and release phosphate in response to environmental conditions; PAOs contain much higher levels of phosphate in their bodies than other bacteria.
- Porosity:** The degree to which a material is permeated with pores or cavities through which fluids and gases, including air, can move. Porosity is measured by the ratio of the volume of air spaces to the total volume of the material.
- Precipitate:** The conversion of a slightly soluble substance into an insoluble substance that settles out of a solution.
- Prepupae:** (*pl.* of prepupa) Insects that are between the larval stage and the adult stage, but must undergo metamorphosis before reaching adulthood.
- Protozoa:** A one-celled animal that is larger and more complex than bacteria.
- Recoverable manure:** Manure that can be collected; cow pies deposited in a pasture are non-recoverable.
- Rhizome:** An underground horizontal stem that produces root systems and new shoots. New plants may be propagated from rhizomes.
- Ruminant:** An animal with a multiple stomach (polygastric) system of digestion capable of digesting cellulose. Cow, sheep, and goats are ruminants.

**Salmonella:** A bacteria found in the digestive tracts of animals that can be the cause food poisoning in humans.

**Scrim:** Woven fabric.

**Short-circuiting:** Incomplete treatment due to the formation of channels of preferential flow bypassing a portion of the treatment system.

**Soil amendment:** Compounds used to build and maintain the physical properties of soil.

**Stabilization:** A microbial process that results in material that cannot be easily decomposed.

**Stolon:** An above-ground horizontal stem that produces root systems and new shoots. New plants may be propagated from stolons.

**Supernatant:** The liquid standing above the layer of solids after settling or treatment.

**Tile drain:** Also called a pipe drain; a buried pipe that conveys drainage water to a central drain or outflow to a stream. Flow from tile drains may be considered point-source pollution.

**Tilth:** The physical condition of a soil in relation to its ability to sustain plant growth.

**Tipping fees:** The fees earned for the collection of unwanted materials.

**Turbid:** Cloudiness caused by particles suspended in liquid.

**Vector:** An agent that transfers a disease or pathogen from one organism to another.

**Xylem:** The vascular tissue in plants that transports water and minerals from the roots to the leaves and other parts of the plant.

**Zeolite:** An ammonia-absorbing material.

# Additional Resources

## ORGANIZATIONS

### **American Farmland Trust**

American Farmland Trust is a private, nonprofit organization founded in 1980 to protect our nation's farmland. AFT works to stop the loss of productive farmland and to promote farming practices that lead to a healthy environment.

[www.farmland.org](http://www.farmland.org)

1200 18th Street NW, #800

Washington, D.C. 20036

Ph: 202.331.7300

Fax: 202.659.8339

[info@farmland.org](mailto:info@farmland.org)

### **Animal and Poultry Waste Management Center**

Animal agriculture in the United States and many parts of the world faces a challenge. If producers are to prosper, they must employ methods of managing the by-products they generate – the manure, litter, mortalities, hatchery, and processing plant offal, and wastewater – that are at the same time environmentally sound, socially acceptable and economically feasible.

[www.cals.ncsu.edu/waste\\_mgt/apwmc.htm](http://www.cals.ncsu.edu/waste_mgt/apwmc.htm)

Waste Management Programs

North Carolina State University, College of Agricultural and Life Sciences

Campus Box 7608

Raleigh, NC 27695

Ph: 919.515.5387

Fax: 919.513.1762

[mike\\_williams@ncsu.edu](mailto:mike_williams@ncsu.edu)

[leonard\\_bull@ncsu.edu](mailto:leonard_bull@ncsu.edu)

### **Animal Welfare Institute**

AWI is a non-profit charitable organization founded in 1951 to reduce the sum total of pain and fear inflicted on animals by humans.

[www.awionline.org/farm](http://www.awionline.org/farm)

PO Box 3650

Washington, DC 20027

Ph: 703.836.4300

Fax: 703.836.0400

[awi@awionline.org](mailto:awi@awionline.org)

### **Center for Rural Affairs**

Establish strong rural communities, social and economic justice, environmental stewardship, and genuine opportunity for all while engaging people in decisions that affect the quality of their lives and the future of their communities.

[www.cfra.org](http://www.cfra.org)

145 Main St - PO Box 136

Lyons, NE 68038-0136

Ph: 402.687.2100

Fax: 402.687.2200

[info@cfra.org](mailto:info@cfra.org)

### **Ecological Farming Association**

The Ecological Farming Association has been at the edge of sustainable agriculture for 25 years. EFA is dedicated to the development of ecologically-based food systems, both domestically and throughout the world by informing farmers, educating consumers and policy makers, and promoting alliances between individuals and organizations.

[www.eco-farm.org](http://www.eco-farm.org)

406 Main Street Ste. 313

Watsonville, CA 95076

Ph. 831.763.2111

Fax. 831.763.2112

[info@eco-farm.org](mailto:info@eco-farm.org)

### **Farmers' Legal Action Group**

Farmers' Legal Action Group, Inc. (FLAG) is a nonprofit law center dedicated to providing legal services to family farmers and their rural communities in order to help keep family farmers on the land. Since its inception, FLAG has provided an extensive array of legal services to financially distressed farmers and their advocates and attorneys nationwide.

[www.flaginc.org](http://www.flaginc.org)

46 E. 4th St., Suite 1301

St. Paul, MN 55101-1109

Ph: 651.223.5400

Fax: 651.223.5335

[lawyers@flaginc.org](mailto:lawyers@flaginc.org)

### **Global Resource Action Center for the Environment**

GRACE works to form new links with the research, policy, and grassroots communities to preserve the future of the planet and protect the quality of the environment.

[www.factoryfarm.org](http://www.factoryfarm.org)

215 Lexington Avenue, Suite 1001

New York, NY 10016

Ph: 212.726.9161

Fax: 212.726.9160

[info@factoryfarm.org](mailto:info@factoryfarm.org)

### **Land Stewardship Project**

The mission of the Land Stewardship Project is to foster an ethic of stewardship for farmland, to promote sustainable agriculture, and to develop sustainable communities.

[www.landstewardshipproject.org](http://www.landstewardshipproject.org)

2200 4th Street

White Bear Lake, MN 55110

Ph: 651.653.0618

Fax: 651.653.0589

[lspwbl@landstewardshipproject.org](mailto:lspwbl@landstewardshipproject.org)

**Leopold Center for Sustainable Agriculture**

The Leopold Center is a research and education center with statewide programs to develop sustainable agricultural practices that are both profitable and conserve natural resources.

[www.leopold.iastate.edu](http://www.leopold.iastate.edu)

209 Curtiss Hall  
Iowa State University  
Ames, IA 50011  
Ph: 515.294.3711  
Fax: 515.294.9696  
[leocenter@iastate.edu](mailto:leocenter@iastate.edu)

**Natural Resources Defense Council**

The Natural Resources Defense Council's purpose is to safeguard the Earth: its people, its plants and animals, and the natural systems on which all life depends.

[www.nrdc.org](http://www.nrdc.org)

Natural Resources Defense Council  
40 West 20th Street  
New York, NY 10011  
Ph: 212.727.2700  
Fax: 212.727.1773  
[nrdcinfo@nrdc.org](mailto:nrdcinfo@nrdc.org)

**Sierra Club**

The Sierra Club's members are 700,000 of your friends and neighbors working to keep animal waste out of our water by stopping factory farm pollution.

[www.sierraclub.org/factoryfarms](http://www.sierraclub.org/factoryfarms)

85 Second Street, 2nd Floor  
San Francisco, CA 94105  
Ph: 415.977.5500  
Fax: 415.977.5799  
[information@sierraclub.org](mailto:information@sierraclub.org)

**Sustainable Agriculture Research and Education (SARE)**

Since 1988, the Sustainable Agriculture Research and Education (SARE) program has helped advance farming systems that are profitable, environmentally sound and good for communities through a nationwide research and education grants program. The program, part of USDA's Cooperative State Research, Education, and Extension Service, funds projects and conducts outreach designed to improve agricultural systems.

[www.sare.org](http://www.sare.org)

USDA-CSREES  
Stop 2223  
1400 Independence Ave. SW  
Washington, D.C. 20250-2223  
Ph: 202.720.5384  
Fax: 202.720-6071  
[jauburn@csrees.usda.gov](mailto:jauburn@csrees.usda.gov)

## RESOURCES

### **Eat Well Guide**

The Eat Well Guide is a free online directory of sustainably-raised meat, poultry, dairy and eggs from stores, farms and restaurants in your area. Simply enter your zip code to quickly find products in the United States and Canada that are healthful, humane, better for the environment, and that support family farmers.

[www.eatwellguide.org](http://www.eatwellguide.org)

### **FoodRoutes.org**

The Food Routes Network is dedicated to reintroducing Americans to their food — the seeds it grows from, the farmers who produce it, and the routes that carry it from the fields to their tables.

[www.foodroutes.org](http://www.foodroutes.org)

### **Invite Mother Earth to Dinner**

What: Earth Dinner – honoring the gift of food on Earth Day

When: April 22 – or any day that calls for special honor

Where: Your house!

[www.earthdinner.org](http://www.earthdinner.org)

### **The Meatrix**

An animated spoof on The Matrix, featuring Moopheus, defender of family farms.

[www.meatrix.com](http://www.meatrix.com)

### **RoboCow**

It's a bird. It's a plane. No, it's RoboCow. Able to leap tall silos in a single bound, this animated environmental advocate uses her ground-scan radar vision to detect on-farm perils of nonpoint source pollution.

[www.agr.gc.ca/pfra/flash/robocow/en/robocow\\_e.htm](http://www.agr.gc.ca/pfra/flash/robocow/en/robocow_e.htm)

### **Slow Food**

An international organization whose aim is to protect the pleasures of the table from the homogenization of modern fast food and life. Through a variety of initiatives, it promotes gastronomic culture, develops taste education, conserves agricultural biodiversity, and protects traditional foods at risk of extinction.

[www.slowfood.com](http://www.slowfood.com)

### **Sustainable Table**

Sustainable Table works to educate consumers and increase demand for sustainable food through awareness campaigns, promotional events, and through offering viable solutions to the factory farm problem.

[www.sustainabletable.org](http://www.sustainabletable.org)