Farm-management & Value-added Economic Benefits to Agricultural Producers
when
Natural Zeolite is added to Animal Feed and Bedding/Pens

Farm-management Benefits with Zeolite in Animal Feed	Value-added Economic Benefits to the Producer
Animal Health & Welfare	
Reduces scours (swine)	Reduces veterinarian costs
Increases ammonia retention efficiency	Lower feed costs through more efficient feed conversion
Improves animal rate of gain (often 5-10%)	Lower production costs; earlier sale
Less watery and odiferous manure	More cost-efficient manure management & handling
Higher quality products	Higher prices for higher quality meat/eggs/milk
Healthier livestock	Less need for antibiotics, less mortality, better community relations, marketing, and "optics"

Farm-Management Benefits using Zeolite in Animal Bedding & Pens	
Animal Health & Welfare	
Reduces mastitis in dairy cows	Reduces vet costs, milk contamination & spoilage, cost efficient bedding
Reduces respiratory and hoof diseases	Reduces veterinarian and treatment costs; less antibiotic use
Healthier livestock	Healthier products, lower mortality, improved profitability
Manure Management	
Manure significantly less odiferous with ammonia	Reduces worker respiratory illnesses and absenteeism
Manure less watery	Reduces labor – manure easier to handle & transport
Manure enriched with zeolite and ammonia/nitrogen	High quality manure marketable for field operation
Manure + zeolite = organic fertilizer	Higher market value / higher profit potential
CAFO Legal Obligations and Community Relations	
Sequestering manure-generated ammonia in zeolite	Minimizes threat of legal liability, minimizes odors, less run-off contamination & algae growth, improves neighboring property values, and positively affects community relations

Attachment A

BioGreen
TECHNOLOGIES INC.

Promoting Healthy Farms from Feed to Field

BioGreen Overview

Introduction

The nation's food supply is in great part supported by large concentrated animal feeding operations, or CAFOs. An unavoidable consequence of CAFOs is the over one billion tons of animal manure produced annually. Ammonia nitrogen losses from manures create health hazards, noxious odors, contaminate waterways, and represent a significant economic loss for the farming system. **BioGreen Technologies Inc**. is a Colorado-based company with the primary goal of supplying **natural zeolites** to CAFOs (including dairy cows, beef cattle, swine and poultry) in order to significantly benefit:

- animal health – when natural zeolites are included in feeds,
- animal health – when natural zeolites are used for bedding,
- agricultural crops – when zeolite-enriched manure is used as a fertilizer,
- farming systems – by exploiting zeolite's ammonia-sequestering capabilities to recycle nitrogen on farms and minimize nitrogen loss,
- farming systems – utilizing zeolite's ability to absorb and release up to 70% of its weight in water, and thus, use irrigation water more efficiently.

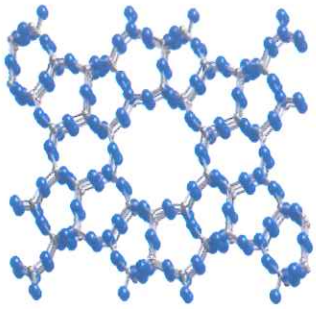
These and other agricultural benefits natural zeolites provide are extensively well documented in the scientific literature (e.g., Pond & Mumpton, 1983, *Zeo-Agriculture: Use of natural zeolites in Agriculture and Aquaculture*). Natural zeolites have long been used worldwide as a slow-release nitrogen fertilizer for agricultural crops, in the aquarium industry for ammonia control, as a high-quality cat litter, for municipal water and wastewater treatment, and for many other applications. This testifies to their valuable properties and capabilities – which are also very beneficial to CAFOs. This is not new science by any means, but rather generally accepted knowledge that has existed for many decades. What we are proposing, however, is a scale of application never before conceived.

"**Every movement has its moment**"… and BioGreen is uniquely situated to make positive impacts at the local, regional and national levels. The BioGreen team includes one of the world's leading experts on natural zeolites, as well as people with extensive experience in international business, production management, mining, agriculture, environmental protection, finance, labor relations and transportation. BioGreen plans to establish production facilities in Mexico with packaging and distribution operations located in Colorado.

Biogreen's Natural Zeolite

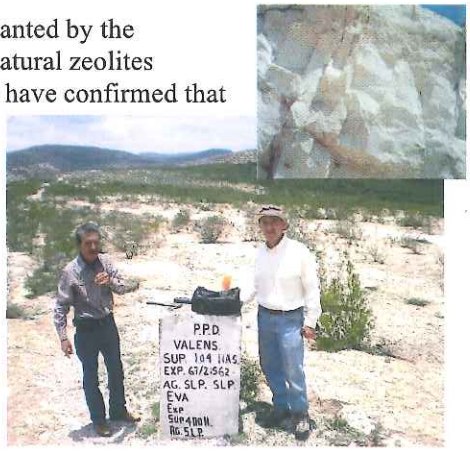
Natural zeolites are the centerpiece of BioGreen's efforts to benefit CAFOs. We recommend their application as a feed additive, for animal bedding, and their incorporation with animal manures to produce a nitrogen-rich, high-quality organic fertilizer for field crops.

First discovered 1756, natural zeolites are hydrated sodium, potassium, and calcium aluminosilicate minerals found in volcanogenic sedimentary rocks worldwide. **Formed by the gradual modification of volcanic ash deposited in lake and marine waters eons ago**, large deposits of natural zeolites were first discovered in the western US, Mexico, Eastern Europe and Asia beginning in the 1950s. This was also about the time synthetic zeolites were being developed as "molecular sieves" for various industrial uses.



There are over 80 different natural zeolites, but only a few common types represent the bulk of the available natural zeolites worldwide. Clinoptilolite $(Na_3K_3)6(Al_{12}Si_{30}O_{72}).24H_2O$, together with heulandite, chabazite, modenite, and philipsite, are the most common types of natural zeolites. Clinoptilolite, like many zeolites, is characterized by a crystalline structure with open three-dimensional channels throughout (illustrated on left). **This lattice, "honeycomb" structure makes zeolite relatively lightweight, soft, and porous.** This unique physical structure – think of a rigid dried-out sponge – is also critical in zeolite's important properties, particularly **ammonia sequestration through cation exchange** and irrigation **water efficiency through dehydration-rehydration**. Natural zeolites are non-toxic, benign, and will cause no harm to the environment.

BioGreen owns a concession (mining claim) in central Mexico, granted by the Government of Mexico, which contains a world-class deposit of natural zeolites consisting of about 60-90% clinoptilolite. Mineralogical analyses have confirmed that this deposit is among the **highest quality and most consistent found in the western hemisphere**. This concession has estimated reserves of over 100,000,000 tons, and we are in the process of acquiring additional concessions containing similar deposits of natural zeolite. Production methods are similar to sand and gravel operations, with the added benefit that no water is used in the process. The photo to the right shows BioGreen President Jorge Oteo (on the right) at BioGreen's concession with Mr. Manuel Lozano, BioGreen's mining engineer in Mexico.



Natural Zeolite's Agricultural Benefits

BioGreen's primary goal is to supply **natural zeolites** to benefit CAFOs, including dairy cows, beef cattle, swine and poultry. Although the term CAFO has legal significance with regards to federal & state regulations, number & type of animals confined, and confinement criteria, we refer to CAFOs generically. That is, natural zeolites can benefit any animal husbandry/agricultural system where animal waste production occurs in a confined area, and large-scale animal waste disposal is an economic and environmental problem.

The two main applications for natural zeolites in CAFOs are in animal feeds and for animal bedding. Including natural **zeolites in animal feeds** has shown to improve animal health, increase weight, improve nitrogen uptake efficiency, reduce infections, and makes the resulting manure less liquid and odiferous. Studies also have shown that including natural zeolites in the feed reduces the farmer's need for antibiotics, supporting the national movement to reduce antibiotic use in CAFOs.

Incorporating natural **zeolites for animal bedding** has shown to significantly reduce odors and excess moisture, thereby significantly reducing risks of respiratory and hoof infections in ruminants and swine, and mastitis in dairy cows. When the manure-zeolite mixture is removed from the pens and used to fertilize agricultural crops, zeolites' ability to sequester ammonia and absorb/release water provides many additional benefits for the farmer.

The two diagrams below highlight the benefits when utilizing **zeolites for agricultural crops,** including recycling nitrogen on farm, minimizing noxious odors, minimizing contamination of airborne and waterborne nitrogen to the surrounding environment, and more efficient use of irrigation water. In both diagrams below, nitrogen comes to the CAFO as animal feed. The blue arrows indicate both the size and path of this nitrogen. About 10-15% of the nitrogen in the animal feed ultimately ends up in the animal, with the remainder excreted. As illustrated below, **incorporating natural zeolites in animal bedding and fertilizing crops with the zeolite-manure increases nitrogen recycling and reuse on farm, improves animal health, and creates a more economically and environmentally sustainable CAFO farming system**.

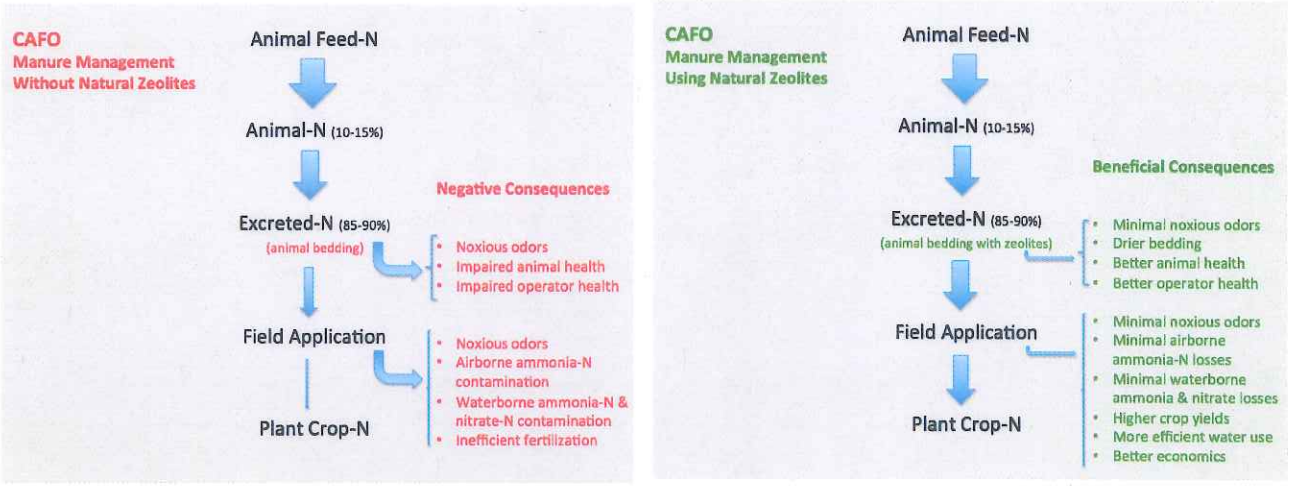


Figure 1. Schematic diagrams illustrate the paths of nitrogen from feed to field without natural zeolites added to animal bedding (left), and with natural zeolites used for bedding (right). The blue arrows show both pathway directions and relative amounts of nitrogen at each level, with corresponding consequences listed on the right.

Minimizing environmental degradation from CAFOs

Nitrogen losses arguably represent the most significant sources of environmental contamination from CAFOs and agricultural fields. Nitrogen can leave the CAFO farming system in two primary ways: airborne and waterborne.

Airborne nitrogen losses: Ammonia-nitrogen (NH_3-N) volatilizes quickly under saturated conditions, allowing ammonia to be windblown away from the CAFO. These conditions develop quickly, as evidenced by the strong ammonia odors emanating from animal pens and feedlots, as well as from

agricultural fields that receive untreated manures. Animal-generated ammonia released into the air not only creates a respiratory health hazard for both animals and CAFO operators, but ammonia's noxious odors also impair the quality of life of the surrounding community. Property values can suffer in communities downwind from CAFOs and create negative economic impacts regionally.

Another environmental issue associated with airborne losses of ammonia from CAFOs is when ammonia is transported to sensitive or fragile ecosystems. A good example is the potential negative impact on Rocky Mountain National Park (RMNP) from cattle feedlot operations in eastern Colorado. Weld County, situated approximately 50 miles from RMNP, has the highest number of cattle and dairy cows of any US county. The Colorado Department of Public Health and Environment recently determined that 92% of Colorado's ammonia emissions come from livestock and agricultural fields. If transport and deposition of this ammonia is left unchecked, RMNP's otherwise pristine lakes may become unsuitable for native trout as aquatic ecosystems degrade due to excessive nitrogen inputs.

Waterborne nitrogen losses: Although it's a gas, ammonia nitrogen is highly soluble in water. Ammonia is released from water as a gas when ammonia concentrations exceed saturation, as demonstrated by the noxious ammonia odors around CAFOs. Ammonia in water is also utilized by nitrifying bacteria that can convert/oxidize high concentrations of ammonia into high concentrations of nitrate (NO_3^-) via a microbial process called nitrification. Nitrate's high solubility facilitates nitrate losses from CAFOS and agricultural fields through leaching into groundwater and surface drainage. High nitrate concentrations in wells and reservoirs can be problematic for water providers when they exceed drinking water safety limits.

Enormous nitrate losses from CAFO/agricultural surface drainage are also largely responsible for the large-scale eutrophication of the nation's waterways. Nitrogen, together with phosphorus losses, promotes toxic cyanobacteria (blue-green algae) blooms and other excessive plant growth that create pea soup conditions in receiving rivers, lakes, and reservoirs. When excessive algal growth dies and sinks to the bottom, oxygen depletion can occur in bottom waters creating hypoxia "dead zones," as documented in the Chesapeake Bay and the Gulf of Mexico.

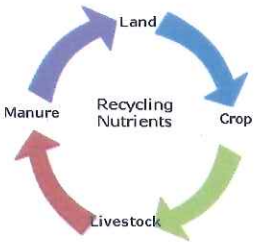
Including natural zeolites in both animal feeds and animal bedding can effectively sequester nitrogen and minimize its losses from CAFOs to the atmosphere, groundwater, and surface water drainage as well as from agricultural field runoff. This "upstream" approach of on-farm nutrient retention and management is critical for farm ustainability and protecting the surrounding enviroment.

Long-term sustainability

Sustainable animal husbandry and agricultural farming systems maintain or enhance the economic viability of the agricultural production and natural resource base, while also minimizing the degradation of surrounding ecosystems influenced by these activities. Some **fundamental principles of sustainable agriculture** include:

- Long-term farm productivity and economic viability of the farming operation, while producing sufficient high-quality and safe foods

- Minimizing adverse impacts to the environment and existing ecosystems
- Minimizing the use of chemical fertilizers and pesticides
- Maximizing the net economic and social benefit by protecting the health and safety of farm workers and local communities



Utilizing natural zeolites in animal feed, animal bedding, and animal manure management achieves all of the goals listed above for sustainable agriculture. Capturing ammonia emissions at the source allows for more efficient nitrogen recycling and minimizes the negative animal and human health impacts, the economic wastefulness, and the serious environmental degradation of our air and water. In addition, **zeolite-enriched manure is a value-added organic fertilizer** that provides numerous economic and agricultural benefits compared with the application of unprocessed manures or synthetic fertilizers.

Furthermore, there is no down side to using natural zeolites for agricultural applications. The more zeolite applied to agricultural fields, the better the farmer will be able to optimize ammonia-nitrogen availability while increasing irrigation efficiency. In fact, plants grow very well hydroponically with a zeolite substrate, as demonstrated for many years on the international space station.

BioGreen Vision and Strategy

The time is right

It is fair to ask, if this is such a great concept, why hasn't been done already? Although the relevant science on ammonia sequestration and agricultural applications has been very well established for decades, natural zeolite deposits in the US are too small to address the magnitude of large-scale manure management. US zeolites are used more for small niche markets like cat litter, closet air fresheners, turf production and aquarium filters. Internationally, the largest zeolite deposits are in China where they are used primarily for construction materials. Furthermore, in the US, agricultural runoff has been considered a non-point source under the Clean Water Act, relieving farmers of discharge permits and incentives to mitigate. However, times have changed. CAFO regulations have become more stringent, and communities nationwide are experiencing – and filing lawsuits about – the environmental degradation caused by uncontrolled nitrogen losses from CAFOs and agricultural fields. BioGreen Technologies, Inc. has perhaps the largest deposits of high-quality natural zeolite in North America, and the motivation and ability to provide a significant benefit for sustainable agriculture at a scale never before imagined, until now. **The time is right, now!**

Favorable Political Climate

The environmental issues associated with current CAFO animal husbandry and manure management have reached national headlines. Animal health suffers because of excess ammonia in the air and excess water in the bedding, while excessive antibiotic use in feeds has resulted in resistant "super bugs" and higher farmer costs. Communities downwind from CAFOs suffer both economically and with respects to quality of life – ammonia not only stinks, it is a human health hazard that drives property values down. **Everybody wants a solution, but nobody wants to pay**!

This is where BioGreen Technologies Inc. comes in. We are providing an environmentally beneficial solution that converts a huge liability (never-ending CAFO manure production) into a valuable agricultural commodity and asset by maximizing nitrogen recycling on farm, thus minimizing negative environmental consequences of both CAFOs and associated agricultural fields.

BioGreen Marketing

As a ***vertically integrated*** company, BioGreen Technologies, Inc. will be able to serve a variety of purchasers – livestock producers, dairies, livestock feed suppliers, wholesalers, and private label retail consumers. BioGreen's ***initial*** marketing goals are twofold:

1. To promote and expand BioGreen through focusing on ***innovative applications*** addressing major environmental issues, for example, **animal *manure management, agricultural sustainability, and natural organic alternatives for biosolids and chemical fertilizers.***

2. To penetrate and expand ***existing zeolite markets*** that are compatible with or a logical extension of the agricultural industry, i.e. livestock feed supplements and animal bedding.

Education is the key

To be successful we need to educate. Local, state and federal legislatures and relevant agricultural agencies need to appreciate that:

- **Natural zeolite is a natural mineral** formed from volcanic ash, has a rigid honey-combed structure, has a strong affinity for sequestering ammonia nitrogen, and has the ability to absorb and release up to 70% of its weight in water.
- **Farmers can benefit from natural zeolites** when used as a feed additive, as a bedding replacement for sand and straw, and when incorporated with manure to produce a nitrogen-rich organic crop fertilizer. This creates a healthier, more sustainable farming environment while creating the potential for substantial economic savings.
- **The surrounding community and environment benefits** by minimizing noxious odors, minimizing airborne nitrogen contamination, minimize waterborne nitrogen contamination from agricultural runoff, reduce irrigation water requirements on farm, and a healthier farm benefits everyone.
- **Natural zeolites capabilities and benefits for agricultural applications** are extremely well documented in the scientific literature, and evidenced by extensive commercial applications for cat litter and ammonia removal in aquaria – PETCO sells zeolite by name.

Our website (***www/biogreen-tech.com***) is designed with the focus on education and establishing scientific and professional credibility.

Competitive Advantages

BioGreen Technologies, Inc. has ***six distinct competitive advantages:***

1. **High-quality zeolite** – predominately clinoptilolite, relatively high potassium:sodium ratio
2. **Low Production Costs** – easily extracted, no overburden, affordable labor
3. **Extensive Reserves** – an estimated 100,000,000 tons with additional deposits pending
4. **Excellent Logistics** – easy access to roads, rail, and ocean transport
5. **Existing Competitors / Available Resources** – US zeolite resources are very limited; a main potential competitor, NM based St. Cloud Mining, has filed a mine shut down request.
6. **BioGreen Team** - BioGreen has assembled a team that includes a world-renown geologist and international authority on natural zeolites, experts in the cattle and dairy industry, Mexican mining industry, Mexican geology, Mexican business community, transportation and logistics, and environmental protection and agricultural applications, as well as several senior technical advisors with extensive experience in the water and agricultural industries.

BioGreen Business Plan

Research and Validation:
The basic science relating to zeolite attributes and applications is well established in many peer-reviewed journals, including a paper by Frederick Mumpton, ***"La Roca Magica" ("The Magic Rock")***, which was presented to the US National Academy of Sciences in 1999. Today, BioGreen is partnering with both the Agricultural Research Development and Education Center (ARDEC) at **Colorado State University, The Ohio State University** Bioproducts Innovation Center, and the Department of Agricultural Engineering at the **University of Illinois** to validate specific livestock and agricultural runoff purification applications.

Business Model:
BioGreen has a solid and well-conceived business plan that is based on a thorough knowledge of the market, competition, entry barriers, supply chain management, cost structures, plant, equipment and personnel requirements, real world expectations, long-term operations, and exit strategy. From extraction to delivery of product, BioGreen is focused on sound environmental stewardship, as well as success and profitability.

Capitalization:
BioGreen will fulfill its capital requirements through a combination of private venture capital, public and private grants for innovative agricultural and environmental practices, and available institutional and equipment supplier loans. Company founders, principals, investors, and certain service providers will participate in the issuance of common stock or convertible debt either for cash or for services rendered in lieu of cash. Investors in the initial funding program will receive the benefit of attractive share pricing or future stock options in order to encourage early investment.

Contacts

Please contact us for any questions regarding investment opportunities, potential demonstration projects, on-going university research projects, and/or zeolite marketing and agricultural applications. **Every movement has its moment, and the moment for BioGreen's zeolite to promote *healthy farms from feed to field* is now!**

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Last updated Nov. 8, 2014

AIR POLLUTION

Ammonia Pollution From Farming May Exact Hefty Health Costs

If the U.S. trade balance has a bright spot, it's farming. The value of agricultural exports has doubled over the past decade, driven largely by demand from China and other developing countries. But when ships packed with corn, wheat, and pork depart for foreign ports, many kinds of pollution are left behind. One is ammonia, which wafts into the atmosphere from fertilizer used on fields and from urine and manure produced by livestock. Ammonia reacts with other air pollutants to create tiny particles that can lodge deep in the lungs, causing asthma attacks, bronchitis, and heart attacks.

A new analysis suggests that ammonia does even more health damage in the United States than was thought. The annual cost—associated with thousands of premature deaths—may even exceed the profit reaped by farmers. Some analysts say the startling numbers highlight the need for greater U.S. regulation of agricultural emissions and a review of farm subsidies. If the pollution caused by farming "makes us worse off, it doesn't make any sense," says Robert Mendelsohn, an economist at Yale University. "Ammonia may be the next big frontier in public health protection," says Paul Miller, chief scientist of Northeast States for Coordinated Air Use Management, an association of air quality agencies, in Boston.

Ammonia enters the air mostly from agriculture, although it can also come from vehicles and wildfires. Emissions are growing worldwide and are largely unregulated. When molecules of ammonia react with oxides of nitrogen or sulfur (NO_x or SO_x) created by burning fossil fuels, they turn into particulate matter less than 2.5 microns wide ($PM_{2.5}$)—the most dangerous kind, for which there is no known safe level.

An extensive study of the burgeoning hog farm industry in North Carolina, completed in 2003, found that ammonia-related $PM_{2.5}$ exacted higher health costs than other farm pollutants. "It was striking," says C. M. Williams of North Carolina State University in Raleigh, who led the study. Other researchers have calculated that the average U.S. health cost of ammonia ranges from $10 to $73 per kilogram.

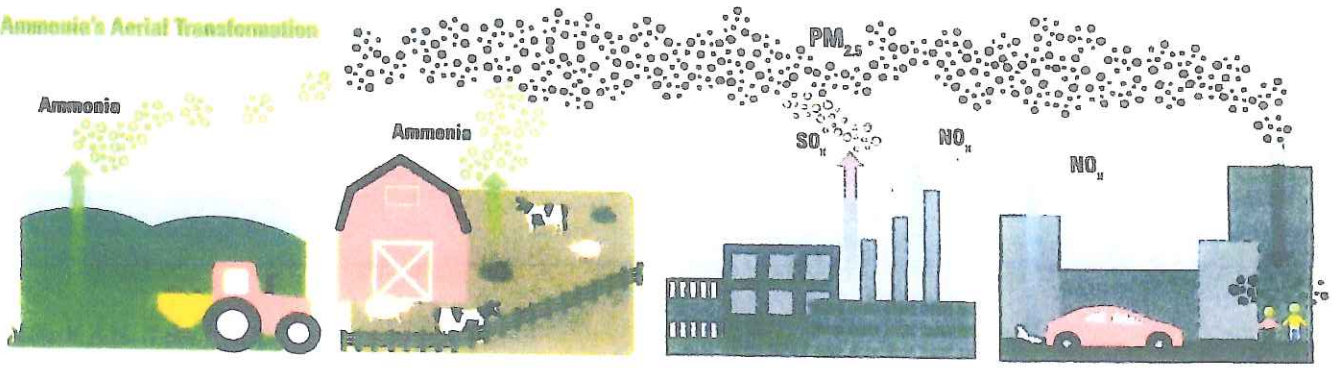
To fine-tune such estimates, Fabien Paulot and Daniel Jacob, atmospheric chemists at Harvard University, developed a new model of where and when ammonia is emitted from farming activities. This model is coupled to another, which accounts for temperature, humidity, and abundance of NO_x and SO_x. "It is a step forward over much of the modeling that's been done before," says air quality modeler Daven Henze of the University of Colorado, Boulder.

Paulot and Jacob used their model to calculate how much ammonia and $PM_{2.5}$ is a result of the food that the United States exports. Next, they used equations developed by the U.S. Environmental Protection Agency (EPA) to calculate the health impact and associated economic costs (calculated by asking people how much they would pay to reduce the risk of premature death). About 5100 people die prematurely each year from $PM_{2.5}$ exposure associated with the emissions, they reported online on 25 December in *Environmental Science & Technology*. Although the health toll varies greatly by location, the burden is heaviest in cities, because of the concentration of NO_x and people. And the total impact is eye-opening: about $100 per kilogram of ammonia, or $36 billion annually. In contrast, the net value of the exported food is $23.5 billion.

Some experts are skeptical of those numbers, pointing out that the new air pollution model has not yet been peer-reviewed and that the health effects of various $PM_{2.5}$ chemistries are still uncertain. "Ammonia emissions do not appear to be a driver of toxicity," says Kathy Mathers of the Fertilizer Institute in Washington, D.C. But Nicholas Muller, an economist at Middlebury College in Vermont, fears that farm-related health costs may in fact be even higher if other farm-related air pollutants are included, such as $PM_{2.5}$ from diesel engines. "This study provides more evidence that, in certain cases, more stringent controls are likely justified," Muller says.

So far, U.S. regulators have neglected ammonia emissions because it has been cheaper and easier to choke off sources of SO_x and NO_x, such as power plants. As a result, states in the heavily populated northeastern United States are already in compliance with EPA limits for $PM_{2.5}$, even though they are downwind of many power plants. But these states are also downwind of major farming areas. If the $PM_{2.5}$ standards are tightened, which is under discussion, ammonia may be regulators' next target.

The biggest gains could be made by keeping livestock and dairy operations away from cities. Best management practices can also reduce losses from fertilizer and livestock. In North Carolina, Williams says he's encouraged that many hog farmers are thinking about generating power from manure, which could reduce ammonia emissions. Other research is investigating how to capture ammonia for use as fertilizer. But with U.S. exports of pork to Asia continuing to rise, it may be a while before emissions in North Carolina and elsewhere start to head down. –ERIK STOKSTAD

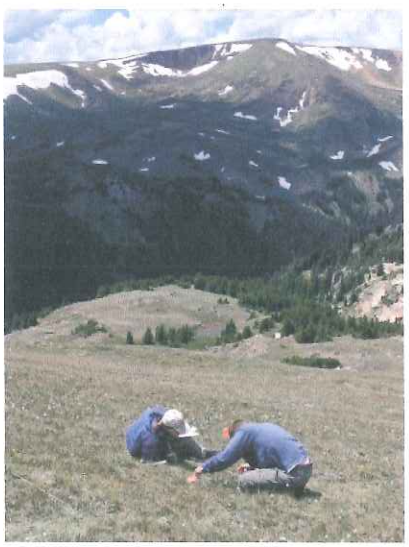


Dangerous reaction. Ammonia (green) reacts with sulfur (red) and nitrogen (blue) oxides to produce tiny, dangerous particles.

CREDIT: C. SMITH/SCIENCE

Nitrogen pollution changing Rocky Mountain National Park vegetation, says CU-Boulder study

July 5, 2012 •
A new study led by the University of Colorado Boulder indicates air pollution in the form of nitrogen compounds emanating from power plants, automobiles and agriculture is changing the alpine vegetation in Rocky Mountain National Park.



Isabel Ashton, left, a former postdoctoral researcher at the University of California Irvine (left), and former CU-Boulder undergraduate John Murgel analyze vegetation changes caused by atmospheric nitrogen pollution in Rocky Mountain National Park. Photo courtesy William Bowman, University of Colorado.

The emissions of nitrogen compounds to the atmosphere are being carried to remote areas of the park, altering sensitive ecosystems, said CU-Boulder Professor William Bowman, who directs CU-Boulder's Mountain Research Station west of Boulder and who led the study. "The changes are subtle, but important," he said. "They represent a first step in a series of changes which may be relatively irreversible."

In other regions of the world, higher amounts of nitrogen pollutants correlate with decreased biodiversity, acidified soils and dead stream organisms like trout, said Bowman. "There is evidence that indicates once these changes occur, they can be difficult if not impossible to reverse. It is best to recognize these early stages before the more harmful later stages happen." The study site was an alpine meadow roughly one mile east of Chapin Pass in the Mummy Range of Rocky Mountain National Park. Bowman and his team analyzed the plant communities and soils under ambient levels of nitrogen deposition and compared them to plots with added nitrogen to simulate the increasing atmospheric nitrogen pollution expected in the coming decades. The results indicated changes in plant abundances already were occurring under ambient conditions, but to date no changes in soils were detected.

During the course of the three-year study, rising levels of nitrogen in the soils correlated with large increases in a common species of sedge shown to flourish in other nitrogen addition studies. Bowman said the team anticipates that the diversity of vascular plant species will rise with increasing nitrogen deposition, then decrease with more rare species being excluded by competition from other plant species. "While the changes are relatively modest, they portend that other more environmentally adverse impacts may be on the horizon in Colorado's alpine areas," said Bowman.

A paper on the subject was published in the June issue of the Journal of Environmental Management. Co-authors on the study included John Murgel, a former CU-Boulder undergraduate student now completing graduate work at Colorado State University, and Tamara

Blett and Ellen Porter of the Air Resources Division of the National Park Service in Lakewood, Colo. The study was funded by the National Park Service.

Previous studies by Bowman and others have shown vegetation changes and soil acidification has been occurring due to increasing nitrogen deposition at other alpine sites in Colorado, including Niwot Ridge. Niwot Ridge is a National Science Foundation-funded Long-Term Ecological Research site administered by CU-Boulder and located adjacent to the university's Mountain Research Station located some 30 miles west of the city.

Given the projected population growth in Front Range cities in the greater Denver area and increasing agricultural development, nitrogen deposition is expected to increase steadily in Rocky Mountain National Park over the next several decades, said Bowman, a professor in CU-Boulder's ecology and evolutionary biology department.

The high-elevation ecosystems of the park are a magnet for thousands of visitors each year who have opportunities to see plants and animals well adapted to the severe climate above treeline, said Bowman, but such ecosystems are the most sensitive to adverse impacts from air pollutants. Previous studies by other researchers have documented ongoing changes in the algae found in several of the Rocky Mountain National Park's high elevation lakes due to nitrogen pollution, he said.

While the park is also a haven for fishermen hoping to catch trout in pristine waters, continued inputs of nitrogen pollutants are a hazard to the health of both trout and their food sources, said Bowman, also a fellow of CU-Boulder's Institute of Arctic and Alpine Research. It starts when the ability of the land plants and soils to take up the nitrogen is exceeded, causing soils to become acidified, he said.

Other parts of the Colorado Front Range have exhibited signs of acidification at the highest elevations, Bowman said. "Once this happens, soluble aluminum leaches from soils and begins to show up in streams and lakes. This aluminum is quite toxic to many aquatic animals," he said. "The take-home message is that the amount of nitrogen deposition reaching the tundra in Rocky Mountain National Park has already passed an important threshold and may lead to more serious environmental impacts," said Bowman. "It's not inconceivable that continued negative ecological impacts in the park due to nitrogen pollution could eventually impact tourism in Colorado."

Officials from Environmental Defense and Trout Unlimited petitioned the State of Colorado and the Environmental Protection Agency to reduce emissions of nitrogen pollution in 2004. This effort resulted in a 2007 plan to lower nitrogen emissions on a voluntary basis to reduce impacts to Rocky Mountain National Park.

Excel Energy's recent switch to natural gas in some of its power plants is one of many steps toward limiting nitrogen emissions, said Bowman. Ongoing efforts by air quality managers and representatives from the Colorado agricultural industry are also working on management practices that would lower nitrogen emissions.

Agricultural Best Management Practices:

Helping to Reduce Nitrogen Impacts at Rocky Mountain National Park

What is the issue and who is involved?

Nitrogen emissions from a variety of human made sources, including ammonia from agricultural production, contribute to an increasing rate of atmospheric nitrogen deposition at Rocky Mountain National Park (RMNP) in Colorado. In 2006, Colorado's crop and livestock producers and researchers at Colorado State University (CSU) began collaborating with the National Park Service (NPS), the Colorado Department of Public Health and Environment, and the U.S. Environmental Protection Agency, to address nitrogen deposition impacts at RMNP.

Why is excess nitrogen harmful to Rocky Mountain National Park?

Although nitrogen is an important part of the park's ecosystems, deposition of excess atmospheric nitrogen at twice the tolerable rate is impacting natural resources. Three-quarters of the park is above 9000 feet where high elevation ecosystems, developed under low nutrient conditions, are especially susceptible to excess nitrogen. Within these ecosystems, alpine tundra, aquatic plants, soil and water quality are most affected. Scientists are also concerned that excess nitrogen may promote non-native plants and reduce forest health. The NPS monitors nitrogen deposition rates and impacts in order to protect RMNP resources for the enjoyment of this and future generations.

What are the sources of excess atmospheric nitrogen?

Nitrogen in the atmosphere comes from a variety of natural and human made sources. Sources of human made or excess atmospheric nitrogen include power plants, vehicle exhaust, oil and gas production, wastewater treatment plants, landfills, fertilized crops, and livestock production, as well as municipal and residential activities such as lawn care. Research shows that excess nitrogen comes into RMNP from both urban and rural areas in Colorado as well as from other states.

How is atmospheric nitrogen transported into the park?

Winds blowing from the west regularly transport to and deposit nitrogen in RMNP. In addition, past weather data and recent research show that common spring and summer weather events, with upslope winds from the east, are transporting and depositing nitrogen in the park. During these weather events, nitrogen is transported by wind, combined with moisture in the air, and then deposited in the park by rain or snow.

What is being done about it?

State and federal agencies are working with industry to reduce significant sources of nitrogen emissions. The State of Colorado will use nitrogen oxide reduction strategies including engine regulations, vehicle standards, and power plant controls to achieve a 41% reduction in statewide nitrogen oxides emissions by 2018. In addition, Colorado's crop and livestock producers are exploring ways to further reduce agriculture's contribution.

Research at CSU is focused on identifying and refining voluntary best management practices (BMPs) for agricultural production activities to improve efficiency and reduce nitrogen emissions from ammonia. Many agricultural producers already employ beneficial BMPs and broader use of science-based BMPs can help reduce emissions even more. BMPs aim to reduce ammonia emissions by: 1) reducing nitrogen inputs, 2) keeping more nitrogen in the final agricultural product, or 3) preserving more nitrogen in the soil on the farm.

For example, one promising BMP being developed by CSU's Dr. Jay Ham, is an "early warning system." This system would advise agricultural producers to avoid high nitrogen-emitting activities, such as certain methods of manure handling and crop fertilizing, during specific weather events that could readily transport nitrogen into RMNP.

Other BMPs being evaluated by CSU include, reducing dietary crude protein and using animal feed additives and hormones. Together these techniques may help increase fed nitrogen retention to improve production or animal rate of gain, and reduce nitrogen lost to the environment. **More information on ammonia BMPs is available at** http://ammoniabmp.colostate.edu.

The efficiency of nitrogen use in crop production is also improving with advances in fertilizer application that optimize fertilizer amount, timing, and placement. Conservation tillage techniques, precision watering, and crop technology are also important ways to improve nitrogen use efficiency.

Why should agriculture producers care about voluntary ammonia best management practices?

Voluntary implementation of ammonia reducing BMPs will benefit Colorado agriculture by:

- Increasing efficiency resulting in the use of less nitrogen, keeping more on the farm for production, and lowering costs.
- Providing producers the opportunity to assist in the refinement of BMPs that are culturally and operationally acceptable and economically viable.
- Reducing the need for mandatory BMPs or regulations in the future.
- Extending land stewardship beyond the farm by helping to address current ecosystem impacts and avoid future impacts to Colorado's natural systems.
- Helping to reduce nitrogen deposition impacts and preserve RMNP and other lands for the enjoyment of this and future generations.

How can producers get involved?

You may join other crop and livestock producers and industry representatives at quarterly meetings of the Rocky Mountain National Park Agriculture Subcommittee which strives to better understand and address nitrogen challenges for both producers and RMNP. This subcommittee reviews BMP science and research, documents agriculture's accomplishments, develops outreach efforts, and exchanges updates and recommendations with state and federal agencies. Adding your voice to this collaborative effort can help keep agriculture on a voluntary and successful path forward.

For more information:

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RMNP air quality websites:
www.cdphe.state.co.us/ap/rmnp.html and
www.nature.nps.gov/air/Permits/aris/romo

Colorado Department of Public Health and Environment

West Greeley Conservation District

Natural Resources Conservation Service

It's Up to Us!

Help Preserve Rocky Mt. National Park

William Faulkner, Ph. D, Texas A&M University

Rocky Mountain National Park (RMNP) is a spectacular natural treasure encompassing 415 square miles of alpine and subalpine ecosystems on the doorstep of Colorado's eastern plains. Nitrogen emissions, including ammonia emissions from agriculture and waste management activities as well as oxides of nitrogen from combustion sources, have contributed to increases in atmospheric nitrogen deposition in the Park that are driving undesirable changes in aquatic and terrestrial ecosystems. The Rocky Mountain Atmospheric Nitrogen and Sulfur (RoMANS) study demonstrated that a substantial portion of nitrogen deposition into RMNP occurs when synoptic-scale upslope events transport air from eastern Colorado and the surrounding region westward into the mountains. Rain or snow produced during these events captures the atmospheric nitrogen and deposits it in the Park. Most of these large events happen in the spring or fall.

In 2013, Colorado's livestock and crop producers and researchers at Colorado State University (CSU), with funding from the Colorado Department of Public Health and Environment (CDPHE) and the National Park Service (NPS), began developing a meteorological warning system to inform crop and livestock producers of impending upslope events that have a high likelihood of moving nitrogen emissions from eastern Colorado into RMNP. By identifying windows of time during which nitrogen emissions are most likely to have negative environmental impacts, producers may be able to avoid practices that have the potential to increase emissions, thereby reducing their environmental impact using voluntary practices that are tailored to a given operation.

The development of the meteorological warning system will provide agricultural producers a valuable tool to reduce environmental impacts of their operations while allowing them to continue to implement practices to maximize the health and welfare of animals in their care. The warning system gives producers the opportunity to voluntarily apply certain conservation management practices to reduce ammonia emissions, which may be infeasible for year-round implementation, during strategic times when they will be most beneficial. The improved flow of information allows producers to be better neighbors and better stewards of our land and water resources while providing management flexibility.

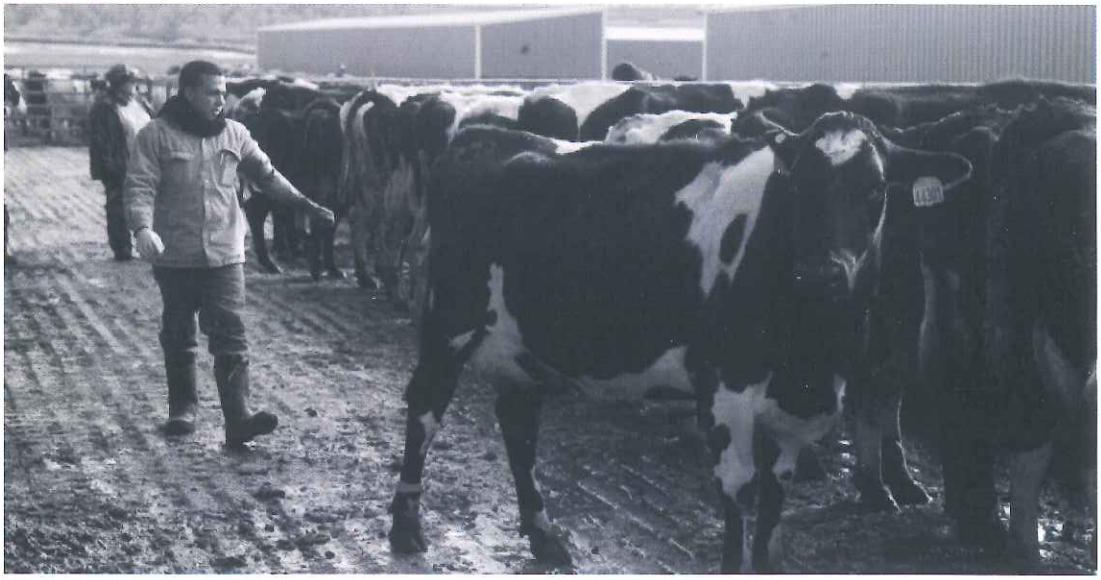
A pilot-scale version of the meteorological warning system is currently being developed with support from CLA, CDPHE, and the National Park Service. The system will be implemented in Spring of 2014, and we're currently looking for volunteers to participate in the pilot-scale study. When an upslope event is predicted, a warning will be issued to agricultural producers participating in the pilot program that conditions are expected that are likely to cause movement of an air mass from eastern Colorado into RMNP. Recipients will be asked to implement management strategies that may reduce emissions or abstain from practices known to increase ammonia emissions, and they will be asked to respond to warnings by indicating their ability to change practices based on the issued warning.

During the pilot project, the effectiveness of the warning system is being evaluated. Producers from a wide range of agricultural operations, including beef cattle feedlots, diaries, swine operations, crop producers, and biosolids application sites are being sought. Data from the pilot warning system project will be 100% confidential and will be used to evaluate and improve the reliability of meteorological predictions and gather data on producer response rates for eventual scale-up to a regional system.

For more information or to sign up for the pilot project, visit www.rmwarningsystem.com, contact Brock Faulkner at faulkner@tamu.edu or contact the CLA office.

Researchers combat illness in dairy workers

by Jeff Dodge | January 8, 2015 9:43 AM



Colorado's dairy workers face a variety of health threats, primarily from inhaling airborne particulates. Photos by Teresa Tellechea

Dairy workers are at heightened risk of developing respiratory ailments because of particles inhaled on the job, and a group of Colorado State University researchers is using a federal grant of nearly $1 million to help find ways to protect their health.

Colorado's dairy industry grew by about 20 percent between 2007 to 2012, when the state's 131,000 milk cows produced more than 3.2 billion pounds of milk, according to the National Agricultural Statistics Service. The number of dairy workers that year, the most recent for which figures are available from the U.S. Department of Agriculture, totaled nearly 3,000, mostly in northeastern Colorado.

These numbers are expected to significantly climb in the next few years primarily because of demand for milk from Denver-based Leprino Foods' huge new mozzarella cheese processing plant in Greeley, Colo.

Leading the research project is CSU's High Plains Intermountain Center for Agricultural Health and Safety[1] (HICAHS). The center is examining the reasons that dairy workers are susceptible to asthma, chronic bronchitis and decreased lung function — and what can be done to decrease the risk.

$900,000 grant

The three-year study is funded with a $900,000 grant from the National Institute for Occupational Safety and Health, part of the Centers for Disease Control and Prevention.

During the project, CSU researchers will work with dairies to measure respiratory responses to airborne particulates, then will design and test interventions to address those responses.

"It's a partnership with the dairy industry on solutions that will work for them," said Stephen Reynolds, a professor in CSU's Department of Environmental and Radiological Health Sciences and director of the High Plains Intermountain Center.

The Colorado State team wants to identify best practices to minimize negative health effects for dairy workers, while also helping dairies to reduce costs associated with employee illness, Reynolds said.

Dairy partners

Some well-known dairy farms already have signed on to collaborate on the Colorado State research project to protect the health of dairy workers.

"We want to be proactive and support this research because we want to deal with any problems our workers may see in the future," said Juan Velez, executive vice president of farm operations for Aurora Organic Dairy. "We believe strongly in employee well-being. So for us it wouldn't be a problem to invest in some improvements to overall employee health. It's the right thing to do."

Reynolds said his center's work with dairies since 2001 has revealed that many workers come into the industry without much experience and can be exposed to materials their immune systems are not prepared for, including dust from fecal matter, animal feed and dander, as well as chemicals used for cleaning facilities.

Dairy workers are responsible for a variety of duties that expose them to dust, including transporting, milking and caring for animals. Most workers are immigrants, young men from

Mexico and Central America, and may not be well-versed in some health and safety measures, he added.

Possible outcomes

The researchers noted that some methods to reduce risk of worker illness might include simple cattle-washing practices, a change in bedding material, a different way of delivering grain, or the addition of vegetable oil to feed rations to reduce dust from manure.

"We're engaging the dairy operators to get their input, to find out what's the least disruptive and most economical," HICAHS postdoctoral fellow Josh Schaeffer said.

The project also is examining the role of bacteria in the health of dairy workers. Emerging evidence suggests gram-positive bacteria may contribute to inflammation and respiratory disease in dairy workers, Reynolds said, and his team is working with biotech company Immunetics of Boston to design a quick diagnostic test for this family of bacteria.

The CSU researchers will design and test interventions, then will examine feasibility.

"This is something else we'll be able to add to our knowledge base," said Jon Slutsky, who owns La Luna Dairy in Wellington. "Maybe when we go to design a building there will be something new to take into consideration. I've always liked collaborating with the university over the years. This is just part of our process for getting better."

The High Plains Intermountain Center for Agricultural Health and Safety is one of 10 regional centers in the United States created by the National Institute for Occupational Safety and Health to address health and safety issues in the agricultural, forestry and fishing industries. The center's annual report is available at http://csu-cvmbs.colostate.edu/Documents/hicahs-2014-annual-report.pdf[2]

Endnotes:

1. High Plains Intermountain Center for Agricultural Health and Safety: http://csu-cvmbs.colostate.edu/academics/erhs/agricultural-health-and-safety/Pages/default.aspx
2. http://csu-cvmbs.colostate.edu/Documents/hicahs-2014-annual-report.pdf: http://csu-cvmbs.colostate.edu/Documents/hicahs-2014-annual-report.pdf

Source URL: http://source.colostate.edu/researchers-combat-respiratory-illness-dairy-workers/

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February 16, 2015

BioGreen Technologies Inc.
Jake Edson – CEO
Jorge Oteo – President
500 Coffman St. Suite 112
Longmont, CO 80501

Dear Mr. Edson and Oteo:

My colleagues and I at Colorado State University would like to express our appreciation to BioGreen for supporting research efforts in our department of Animal Science. We have completed the lab analysis for the pilot project we conducted in the Fall of 2014. This letter will serve to summarize our findings. If you would like the specific data, we can supply that to you upon request. Our hope is that this is the beginning of a long relationship of scientific discovery.

The most interesting finding on this project was one sample in which we treated the manure with urea (organic N form) and zeolites. While we only had the one sample, we did see a significant increase in N retention in that sample. The most common form of N volatilization from livestock is primarily in urine. We believe that the zeolite will bind the ammonia form in the urine much stronger therefore limiting the volatilization of ammonia into the air. Volatilized ammonia is most commonly associated with a very undesirable odor which may be toxic to animals and humans. This finding is likely the most intriguing about this very small study.

The front range of Colorado is struggling to minimize the effects of nitrogen emissions. These emissions are from a variety of sources but livestock urine is a significant source. We believe that zeolites have the potential to play a key role in binding nitrogen from livestock. We have future projects in mind that we are eager to discuss with you at your convenience.

Again, thank you for the opportunity to work with BioGreen.

Sincerely,

R Kraig Peel

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