

Evaluation of technical and economic feasibilities for energy and compost production from dairy manure waste in Coahuila, México



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Description of the Project

- The New Mexico dairy industry comprises of about 320,000 heads. Similarly, 'La Laguna' in Mexico has 440,000 milk cows.
- The dairy industry plays a major role in the economy of both regions.
- However, it is also a source of environmental concern due to the large amount of animal manure that is being generated.
- Faculty at NMSU has been working on technologies to convert dairy manure into energy (biogas) and compost or soil amendment.
- The technology is developed for dry climates with limited water supplies and solid manure (>18% total solids).
- The main objective of this project is to evaluate the technical and economical feasibilities of converting manure waste in Coahuila into energy and compost.

Description of activities

- Literature review: search for technologies for manure treatment.
- Collection of information about dairies location in New Mexico and Coahuila.
- Meetings between participant institutions for information exchange.
- Conference presentations directed to students, faculty, and the community, in both regions.
- Visits to selected local dairies in New Mexico and Coahuila to collect information including: herd size; manure generation, handling, collection and disposal systems; current treatment or disposal alternatives.

Literature Review

- **Anaerobic Digestion Process:** natural process performed by microbes in the absence of atmospheric oxygen to break down organic matter into simpler molecules.
- **Factors Affecting Methane Production:** organic substrate, nutrients, solids and moisture content, temperature, pH, presence of toxic materials (ammonia, hydrogen sulfide, antibiotics), loading rate and, volatile acids concentration.
- **Types of Anaerobic Digesters for Manure Management:** three types of AD systems for biogas recovery are common in the US agricultural community: *covered lagoons, completely mix reactors and, plug-flow reactors.*
- **Alternative technology: two-phase anaerobic digestion system.** This technology has been developed and proved at NMSU and is suitable for dry manure (total solids > 12%).

Environmental Impact of Unmanaged Manure

- Odor
- Flies
- Pathogens
- Release of nutrients: nitrogen, phosphorus
- Biochemical oxygen demand (BOD)
- Carbon dioxide and methane emissions to atmosphere
- Contamination of air, water, and soil

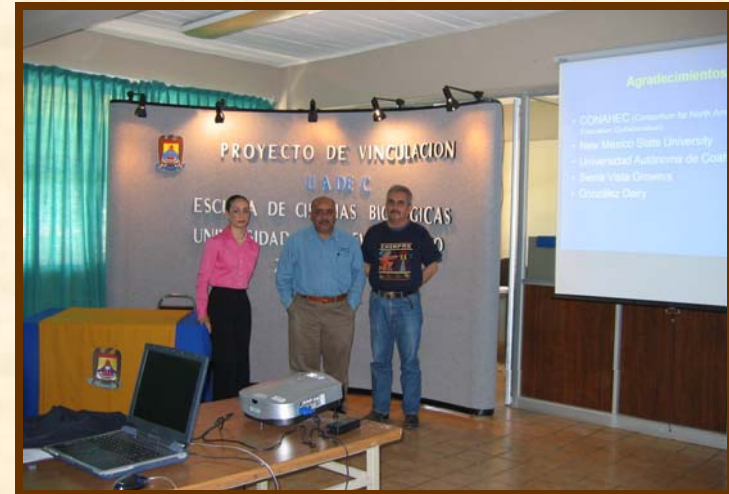
Information Exchange

Meetings and Conferences

Dr. Samani's speech at Universidad Autónoma de Coahuila (Torreón, Coah. Mexico)



Conference at Universidad Autónoma de Coahuila



Poster presented at New Mexico State University (Las Cruces, NM, USA)



TWO COUNTRIES, ONE COMMON ENVIRONMENTAL PROBLEM: MANAGING AGRICULTURAL WASTE

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ABSTRACT

The United States and Mexico have a common environmental problem: **agricultural waste**. The dairy industry plays a very important role in the economy of both countries. However, it has also been considered as a threat to contamination of air, water and soil. Southwest New Mexico and Coahuila, México are two major dairy producers with a considerable high amount of animal manure to be disposed of. Anaerobic digestion (AD) is an alternative for manure treatment. This technology has been proven in southern New Mexico using a two-phase pilot-scale unit built and operated at NMSU to produce energy and soil amendment. The objective of this study is to evaluate the technical and economical feasibility of converting manure waste in Coahuila, México into biogas and compost. Preliminary results of this study showed that the dairy and manure management practices are similar in both regions. In addition, manure and aerobic compost had comparable composition. Coahuila has a considerably warmer climate than New Mexico which makes anaerobic digestion even more suitable for application. Technically, the AD technology has potential to be implemented in Coahuila, México as an alternative for manure management. The economical analysis is in progress.

INTRODUCTION

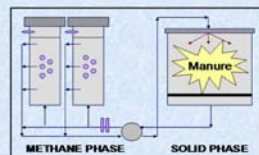
The dairy industry in New Mexico comprises of about 320,000 milk cows. The dairy is the number one cash producing industry in the state, as well as a source of environmental concern due to the large amount of manure that is generated. Similarly, the Mexican state of Coahuila, particularly the area known as "La Laguna", is a major dairy producer. The total number of milk cows in La Laguna has been estimated at 440,000, resulting in more than a million tons of manure per year. Improperly managed animal waste has potential adverse environmental impact due to uncontrolled methane emissions, release of nutrients, and contamination of air, water, and soil. Traditionally, manure has been applied to agricultural lands as soil amendment. However, due to the high cost of transportation, salinity problems in the soil, and limited water supplies in both areas, land application of dairy manure is not economical. An alternative manure management approach would be to convert the waste into energy (biogas) and soil amendment (compost) using an **Anaerobic Digestion (AD)** system.

OBJECTIVES

To evaluate the technical and economical feasibility of converting manure waste in Torreón, Coah. into energy (biogas) and soil amendment (compost).

MATERIALS & METHODS

The project is composed of three parts: applied research, field data collection, and education.



APPLIED RESEARCH (NMSU)

Involves using a two-phase pilot-scale anaerobic digestion (AD) system operated at NMSU to generate energy and compost. The system is fed with dairy manure as mono-substrate or combined with other types of organic feedstock, including municipal solid waste, cotton gin waste, paper, and grass. This part of the projects includes sampling and laboratory analyses.



United States - México
Research Collaboration



DATA COLLECTION - FIELD RESEARCH

It is being conducted in southern New Mexico and Torreón, Coah., México to collect information about dairy industry status, herd sizes, manure management practices, and characterization of manure samples in both areas. This part includes visits to selected local dairies in southern New Mexico and Torreón, Coah., México.

EDUCATION

The educational component refers to conference and public presentations in these communities to inform the public (students, researchers, farmers, local authorities, non-governmental organizations, and citizens) about the purpose, impact, results, benefits, and conclusions of the study.

RESULTS

Quantitative

Table 1 Manure generation

Parameter	New Mexico	La Laguna
Herd size (cows in production)	320,000	440,000
Manure generation (dry, kg/cow/yr)	2,514	2,660
Solids content (%)	18 - 20	19

Table 2 Energy potential in New Mexico

4.3×10^6 18 BTU/year	24,000 KW power generator
210 millions KWh/year	\$21 millions/year

Table 3 Manure and compost composition

Parameter (percent)	New Mexico			La Laguna	
	Manure	Anaerobic Residual	Aerobic Compost	Manure	Aerobic Compost
Nitrogen	1.80	2.32	0.90	1.25	1.15
Phosphorus	0.52	0.15	0.20	0.64	0.49
Potassium	2.01	0.42	2.72	2.75	1.24

Qualitative

One of the premises of this study was to promote technical and scientific information exchange between participant institutions. To achieve this goal, several meetings and conference presentations have been held in Torreón, Coah. Participants attending the meetings included college students, researchers, regulatory agencies representatives, non-profit organizations, and general public. Currently, there are several institutions and private investors interested in the project and exploring the possibility to build an experimental unit.



Importance of the study

This project is a joint collaboration between New Mexico State University and Universidad Autónoma de Coahuila as part of bi-national efforts to improve people's life quality in border communities. This study is intended to serve as an initial step to strengthen international research and academic collaboration between institutions of the United States and México.

CONCLUSIONS

Dairy management practices in and regions are markedly different from those of areas where climate is not so drastic. Solid waste treatment technology suited to regions where water is not a restricted use resource cannot be transferred to those and zones without major modification. Anaerobic digestion (AD) makes use of several microbiological processes to convert organic waste into biogas. Benefits that can justify AD systems are not limited to the economics. It has also to be taken into account the non-quantitative impacts such as environmental (odor control and water pollution prevention), and biosecurity (pathogens reduction).

The research in New Mexico showed that using the two-phase AD system dairy manure can be converted into biogas and soil amendment. The residual from AD has higher nitrogen content and less sodium than the aerobically composted manure. In addition, the AD system used for this study requires considerably less amount of water and time to produce compost, compared to traditional aerobic composting processes in New Mexico and Coahuila. Technically, the AD technology has potential to be implemented in Coahuila, México as an alternative for manure management.

FUTURE WORK

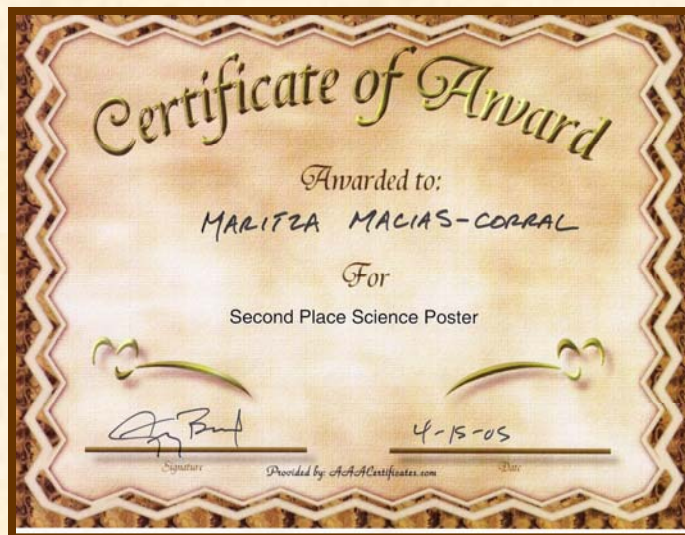
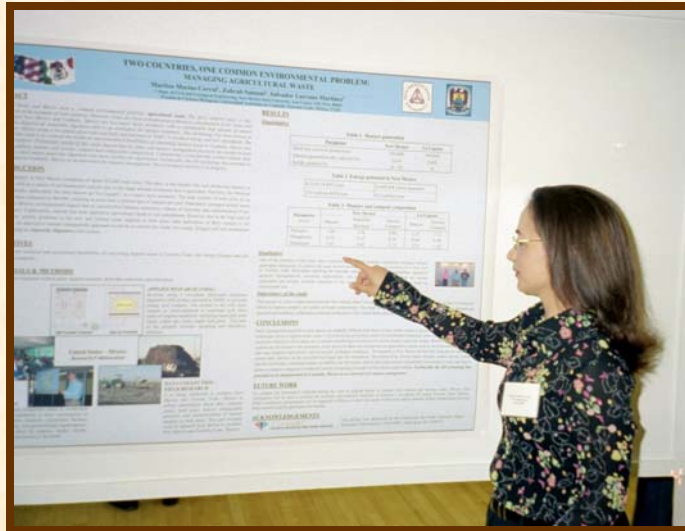
To compile the information collected during the visits to selected dairies in southern New Mexico and Torreón, Coah., México. This information will be used to evaluate the technical and economic feasibility to construct a two-phase AD system Torreón, Coah., México. Public conference presentations will be organized in México to show the results of this study and to promote further collaborations between both countries and the participant universities.

ACKNOWLEDGEMENTS



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Award received for poster presented at NMSU



Field Work

Visits to local dairies in New Mexico and Coahuila

Dairy Operations in New Mexico and Coahuila

New Mexico

- There are approx. 190 dairies.
- New Mexico is currently ranked 7th in the United States for milk production.
- Manure management systems:
 - Aerobic composting
 - Land application (after composting)
- Manure characterization:
 - Solids: 18 – 20%
 - Nitrogen: 1.80%
 - Phosphorus: 0.52%
 - Potassium: 2.01

La Laguna

- La Laguna ranks 2nd in Mexico for milk production.
- Manure generation has been estimated to be around one million tons per year.
- Manure management systems:
 - Direct land application
 - Aerobic composting
- Manure characterization:
 - Solids: 19%
 - Nitrogen: 1.25%
 - Phosphorus: 0.64
 - Potassium: 2.75%

Potential Value of Manure

New Mexico

- 320,000 heads
- 4,100 kg dry manure/cow/yr
- 1.59×10^{12} BTU/year
- 20,000 KW power generator
- 187 Million KWh/year
- \$19 Million/year

La Laguna

- 440,000 heads
- 4,300 kg dry manure/cow/yr
- 2.19×10^{12} BTU/year
- 30,000 KW power generator
- 257 Million KWh/year
- \$20 Million/year

Dairy Operations in New Mexico and Coahuila



Geographical positions of New Mexico and Coahuila

Sources: www.worldatlas.com, <http://www.cia.gov/cia/publications/factbook/geos/mx>

Dairy Operations in New Mexico



Dairy complex in Doña Ana County, NM

Lagoons for liquid effluent storage

(The purple color is due to sulfur reducing bacteria and algae activity)

Open corrals with sunscreens to provide shade

Cows bedded on a manure pack.
Other types of bedding are woodchips, paper, and sand.



Dairy Operations in New Mexico



Indoor housing and feeding lanes



Haflinger Dairy auger truck
removing manure from the feed lanes



Outdoor feeding lanes



Dairy Operations in New Mexico



Manure flushing system



Screen solid-liquid separator



Solid manure



Loading manure for research

Dairy Operations in New Mexico

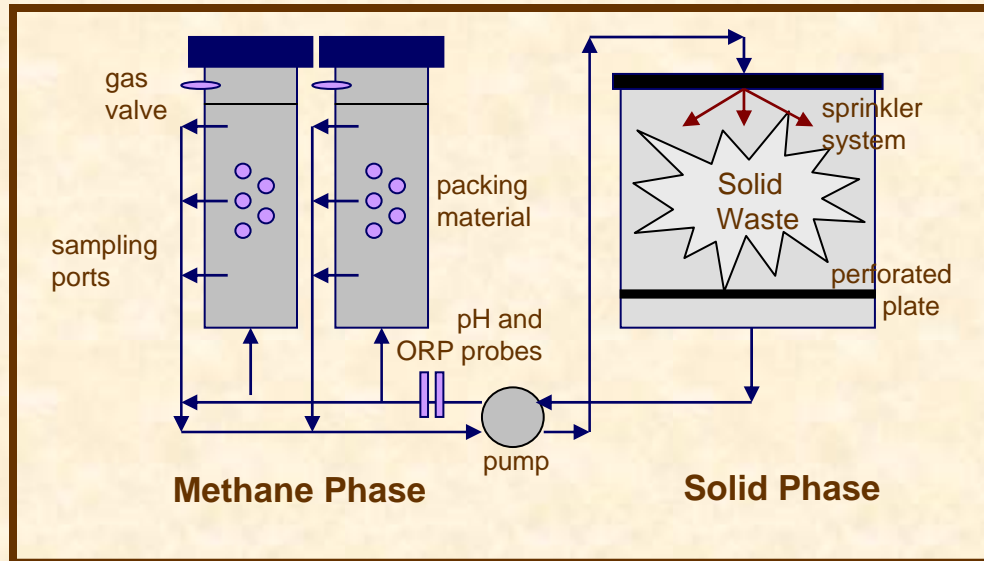


Dry manure stack



Lagoon for liquid effluent storage

Pilot-scale Two-phase Anaerobic Digestion System (NMSU)



The solid phase reactor is loaded with the manure. Water is added from the top to flow through the waste. At an optimal pH level, the liquid is transferred to the methane columns where biogas is produced by bacteria.

The biogas produced in the methane columns is measured using wet-tip gas meters.

(Please, **double-click on image** to watch video taken during biogas production).



Dairy Operations in La Laguna

(aerial views)



Dairy Operations in Coahuila



Open corrals, sunscreens and feeding lanes at local dairies in Coahuila, Mexico



Dairy Operations in Coahuila



Dairy Operations in Coahuila



Cows taking a “shower” before entering the milking parlor



Interior of small (750 heads in production) milking parlor

Dairy Operations in Coahuila



Milking parlor cleaning by flushing system



Dairy Operations in Coahuila



Liquid effluent (wastewater, urine, etc.) from milking parlor.

It is sent to a concrete tank and mixed with irrigation water for alfalfa and other types of forage.

Dairy Operations in Coahuila



Manure collection from corrals, transportation in trucks and disposal for composting



Dairy Operations in Coahuila



Aerobic composting, transportation, and application to agricultural land (alfalfa)



Dairy Operations in Coahuila



Composting of combined dairy manure and tomato waste
and application to agricultural lands (tomato crops)



Conclusions

- Technically, anaerobic digestion technology is suitable for dairy manure management in Coahuila.
- Due to the high solids content in manure, traditional AD systems would have to be modified.
- A two-phase digester could be an alternative. This technology has been proved at pilot-scale in New Mexico.
- Regulations in Mexico for auto-generation of electricity should be carefully observed.
- An economic analysis for full-scale AD technology has not be performed yet.
- Benefits of AD include, but are not limited to:
 - Odor reduction
 - Energy generation
 - High quality compost

Acknowledgements

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