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ATINER's Conference Paper Series

ENV2012-0104

Integral Development of a Project for the Improvement of Operation of Municipal Slaughterhouses, and the Technology of Sustainable Use of Their Waste and Wastewater

Adrián Rodríguez,
Jesús Cárdenas,
Lucila García,
Mario Villalón,
Carlos H. Muñoz,
José A. Ramírez

Center of Research and Technological Development in Electrochemistry,
Parque Tecnológico Querétaro s/n, Sanfandila,
México

Athens Institute for Education and Research
8 Valaoritou Street, Kolonaki, 10671 Athens, Greece
Tel: + 30 210 3634210 Fax: + 30 210 3634209
Email: info@atiner.gr URL: www.atiner.gr
URL Conference Papers Series: www.atiner.gr/papers.htm

Printed in Athens, Greece by the Athens Institute for Education and Research.

ISSN **2241-2891**
5/09/2012

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This paper should be cited as follows:

Rodríguez, A., Cárdenas, J., García, L., Villalón, M., Muñoz, C. H. and Ramírez J. A. (2012) "**Integral Development of a Project for the Improvement of Operation of Municipal Slaughterhouses, and the Technology of Sustainable Use of Their Waste and Wastewater**" Athens: ATINER'S Conference Paper Series, No: ENV2012-0104.

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José A. Ramírez

Center of Research and Technological Development in Electrochemistry, Parque Tecnológico Querétaro s/n, Sanfandila, México

Abstract

In order to analyze the current process of operation of slaughterhouses and propose actions for an appropriate control, as well as implement the reduction of water used per slaughtered animal, this study of green production applied to the processes in a selected municipal slaughterhouse in *Querétaro,* Mexico was undertaken. Also, from treatability tests of wastewater, a mobile prototype of water treatment (1.5 m^3/day) was conceptualized, designed and built. This prototype is operating at the slaughterhouse and demonstrates the efficiency of treatment of those waters. Along with the prototype, this project developed a technological folder with technical specifications, comparative analysis of production units and a business plan that brings together all the necessary information to evaluate the project and the general guidelines to implement it in other municipalities of *Querétaro*. The business plan is essential to seek funding, partners or investors, and serves as a guide for those leading the implementation of the results obtained in this project at other municipalities. Additionally, an environmental impact study was performed to identify and interpret the environmental impacts of a full scale project, with emphasis on environmental benefits.

Keywords: integral, prototype, slaughterhouse, wastewater.
Acknowledgments: Thanks to Tania Penélope Salomón López and René Pérez Martínez for their valuable collaboration in the development of this work.

Contact Information of Corresponding author:

Introduction

Nowadays, talking about environmental problems has become a topic of interest and of great importance in the world, due to the impact on continuity of life in a balanced environment through sustainable development. Fast industrial and technological developments, coupled with increasing human population, have caused serious pollution problems, shortages, natural resource depletion, climate changes and imbalances in ecosystems. The livestock sector is an industry of prime importance, and may be defined as the breeding and exploitation of animals (pigs, cows, sheep, etc.) to get the most out of them. While the primary objective of this activity is to provide food for human consumption, mainly meat and milk, other benefits include the skin, wool, leather, bristles, fat, bone and animal waste products for countless uses such as shoes, blankets, brushes, soap, glue, crafts and composting. In Mexico, this activity is one of the most important agricultural sectors, representing 3.2% of GDP (INEGI, 2009a). Meat production in sanitary conditions is a collective need of the utmost importance. The facility responsible for meeting this need in our country is known as a slaughterhouse. A slaughterhouse is any setting where the slaughter and dressing of animals, or butchering, (NOM-194-SSA1-2004) is carried out. In addition to the above major products, various solid and liquid wastes such as offal, hair, hooves, horns, rejected meat, ruminal and intestinal contents, blood and washing water are generated in slaughterhouses. These residues by their nature are considered to be special handling wastes, which are those generated in production processes that have the characteristics to be considered as hazardous waste, but they are not considered solid waste under the General Law for the Prevention and Management of Waste (LGPGIR, 2007).

The amount and composition of liquid and solid wastes generated in the process of butchering depend on the type of animal that is slaughtered, the slaughter methods and the type of equipment used. Table 1 presents the main sources of generation within a typical slaughterhouse.

Handling and disposal of waste from the slaughter of animals are generally conducted in an inappropriate manner. This process generates wastewater consisting of blood and washing water, and is poured directly into the sewer and water bodies despite having concentrations greater than 30,000 mg COD / L. This causes serious problems in the receiving body, such as eutrophication (Castañeda, 2007). Moreover, solid waste is taken to landfills or open dumps, which lack the necessary measures to capture leachate or greenhouse gases (GHGs) produced by the anaerobic decomposition of organic matter, also of direct and indirect consequence to human health. To alleviate this, waste must be treated before disposal. Slaughterhouse waste anaerobic treatment has not been studied in depth, with most information about the treatment of the liquid fraction. Mark et al (2003), conducted a study of slaughterhouse solid waste slurry (with a ratio of 6% solids, 10% blood and 84% cleaning water) in a mixed reactor where continuous removal efficiencies of 22% organic matter and biogas yield of 7.84 L per kg of residue added were obtained. Alvarez, (2004), performed a codigestion of slaughterhouse waste and debris from the market, comparing different solids loadings and determined that the appropriate concentration was 4% of volatile solids (VS) to obtain a productivity of 557 L of methane per kg VS fed. Subsequently, as the process was carried to laboratory scale, the following factors were investigated for their effect on production of biogas and reduction of volatile solids: temperature, composition of the mixture, retention time and percentage of volatile solids in the feed. From this it was

determined that the most suitable temperature was 36 ° C, with a proportion of 17% market waste , 67% mixed rumen / blood and 17% manure. The yield of methane was 634 L per kg of VS added.

In the State of Queretaro Mexico, there is a pressing need for action to reduce pollution from municipal slaughterhouses and slaughterhouses in general. In 2007 the *Centro de Investigación y Desarrollo Tecnológico en Electroquímica* (CIDETEQ), in collaboration with the *Secretaría de Desarrollo Sustentable* (SEDESU), conducted a census of the main municipalities of the State of Queretaro to identify needs in the matter of slaughterhouses and improvements to treatment plants. It was found that the municipalities of *El Marqués, Huimilpan, Peñamiller, San Joaquín, Landa de Matamoros* and *Arroyo Seco* do not have slaughterhouses, requiring slaughter of livestock in non-commercial houses or transport of particular animals to neighboring municipalities. The municipalities of *San Juan del Rio, Tequisquiapan, Ezequiel Montes, Colón, Tolimán, Cadereyta, Pinal de Amoles, Jalpan, Querétaro, Pedro Escobedo* and *Amealco* were visited, resulting in the finding that only *San Juan del Rio* has some pilot anaerobic reactors (designed and manufactured by CIDETEQ), and that only 10% of the 36 m^3/day of generated wastewater is treated, discharging the rest to the *Rio San Juan*. The slaughterhouse of *Tequisquiapan* has some aeration pits, and the rest of the municipalities do not have any water treatment systems specifically for slaughterhouse waste. Municipalities with greater generation of slaughterhouse wastewater are *Querétaro* (216 m^3/day) and *San Juan del Rio* (36 m^3/day), followed by *Amealco* (9.7 m^3/day), *Colon* (7.8 m^3/day), *Tequisquiapan* (5.8 m^3/day), *Pedro Escobedo* (5 m^3/day), *Ezequiel Montes* (3.2 m^3/day), *Tolimán* (3 m^3/day), *Cadereyta* and *Pinal de Amoles* (2.5 m^3/day each) and *Jalpan* (1.8 m^3/day). The discharges of most municipalities are made directly to the sewer system, except for *Colón*, which discharges to the Solitude Dam reservoir, *San Juan del Rio* to *Rio San Juan*, and *Querétaro* to an interceptor line that goes directly to *Rio el Pueblito*. In CIDETEQ, studies have been conducted to determine whether slaughterhouse residues can be treated through a process of biological transformation efficiently, called anaerobic digestion, concluding that this technique of treatment for solid and liquid waste ensures the elimination of pollutants, produces a renewable fuel (biogas) and obtains a stabilized product capable of being used as fertilizer or soil improver. This project presented an excellent opportunity to define the complete methodology to optimize and standardize the operation of the slaughterhouses, attacking the problem from the standpoint of reduction of wastewater generation. The development of the business plan and environmental impact study allowed more emphasis on economic and environmental benefits represented by the installation of this system in different municipal slaughterhouses. The business plan and environmental impact study also helped to promote the strategy with State and municipal governments and institutions such as SEDESU and SEMARNAT, which each municipal slaughterhouse operate its water treatment system and reap the benefits mentioned above. In order to help in the reduction of the pollution generated from slaughterhouses in the State of Queretaro, this project proposed the following goals.

1. - Conduct a study of cleaner production for municipal slaughterhouse operations, focused on the continuous application of an integrated preventive environmental strategy applied to processes, products and services to improve eco-efficiency and reduce risks to humans and the environment.
2. - Design and construction of a prototype wastewater treatment unit, with a capacity of 1.5 m^3/day, to operate at a demonstration site.

3. - Development of an Environmental Impact Assessment of the proposed prototype, to identify and interpret the environmental impacts of the project.
4. - Development of a Business Plan comparing traditional and new alternatives.
5. - Development of a folder with technical information and technological comparative analysis of production or treatment units.

Methods

The following methodology was used in this study:

For the study of Cleaner Production:

1. - Context analysis of the competitiveness of the slaughterhouse and its strengths and weaknesses: We determined the characteristics (strengths and weaknesses) of the slaughterhouse, within the scope of application of the strategy for Cleaner Production (CP), and examined what factors influence them (such as constraints and opportunities). Literature on major international environmental trends affecting the business was reviewed. Various sources of information were consulted for analyzing the business environment of the slaughterhouse. Internal weaknesses that limit the development of alternative preventive strategies for CP were evaluated. Alternatives applicable to slaughterhouses were identified and analyzed, as were the characteristics of similar projects and companies through case analysis.
2. - Description of the environmental problems of the slaughterhouse: Laws, Rules and Regulations on environmental issues that relate to the slaughterhouse and applied CP tools were reviewed to identify critical points, from both environmental and economic standpoints. The root causes of each critical point were determined. The efficiency and inefficiency at each critical point, and their associated costs, were measured and determined.
3. - Project identification and design improvement and development of the CP plan: Potential alternatives (improvement projects) were identified for improving business competitiveness and environmental performance of the company. Issues of financing, markets, etc., were reviewed to determine potential barriers to the implementation of alternatives.

For the design and construction of the prototype:

1. - Literature review of the processes, sources of biomass, energy potential, industrial water characteristics, and determination of the industrial world: A key aspect in solving a problem is understanding it, so much attention was given to this activity. The processes under study are complex; therefore all existing technologies were evaluated in order to obtain results that are robust and applicable to the slaughterhouses.
2. - Characterization of wastewater: Samples of wastewater were collected for analysis. From the results of analyses, organic content was determined and the appropriate type of anaerobic process was selected.
3. - Anaerobic digestion tests at laboratory level: Following the wastewater characterization and selection of the appropriate process, many laboratory level trials were performed. Different reactors were tested, and the results evaluated, to choose the one that would lead to the next step, a pilot demonstration.

4. - Basic engineering of the prototype: This refers to the functional design (shape, overall dimensions, types of equipment needed, main characteristics of operation, etc.) of the units that process the wastewater.
5. - Detailed engineering of the prototype: This consists of the hydraulic, electrical, and civil design of the digestion modules, from the input of wastewater to the biogas output.
6. - Construction of a prototype of wastewater treatment for biogas production: With the preceding information, we constructed the prototype for an efficient and inexpensive wastewater treatment system.
7. - Start-up and operation of the prototype: Function tests were performed with analysis of treated water.
8. - Preparation of the operating manual.

For the Environmental Impact Assessment:

1. - Visit and tour in the study area (slaughterhouse).
2. - Collection of general information about the slaughterhouse.
3. - Mexican environmental legislation and the legal framework governing the operation of the slaughterhouses.
4. - Description of the current problems of the slaughterhouse in question with emphasis on the treatment of wastewater.
5. - Identification, assessment and classification of current and future environmental impacts with the implementation of the project, by applying the methodology of environmental impact analysis.
6. - Comparison of scenarios, with analysis of current situation vs. project alternatives.
7. - Conclusions.

For the development of a Business Plan:

1. - Project summary: In this first part of the Business Plan, the executive summary, we pointed out the basic project data, and provided a summary of the business plan (including the other parts that comprise it). In addition we summarized the entire project.
2. - Market research: In the second part of the Business Plan, or market research, we investigated, analyzed and documented everything about the market: what or who will be our target market, our future demand, our competitors, our suppliers, and our marketing strategies (a. definition of market profile, b. analysis and forecast of demand, c. competitive analysis, d. marketing analysis, e. market analysis provider).
3. - Technical study: In the third part, all the processes that shape the project are designed and defined, including the procurement process, transportation, storage, production, distribution, sales, etc. We noted the phases or stages that make up each process, the staff, the provision of productive area, the location of the machines, the technical aspects, etc.
4. - Investment study: In the fourth part, we made a list of assets and working capital that are required (based on market research and technical study done previously) before starting operations, with their estimated costs.
5. - Income and expenses study: In part five, we developed projections of project revenues and expenditures (projected cash flow and projected income statement). In

the case of using external financing, debt was first projected, then the projections of revenues and expenses.
6. Financial study: Finally, in part six, we evaluated the feasibility and profitability of the project, taking into account the investment studies and the study of income and expenses done previously.

For the development of a technological folder:

1. - Collection of information.
2. - Integration of a technology folder, containing: the Cleaner Production study, a Specifications and Operation Manual of the prototype, the Environmental Impact Assessment and the Business Plan: This folder will allow the transfer of technological knowledge generated in this project to other municipal slaughterhouses within Queretaro State.

Results

The results obtained with this work are the following:
1. - Study of municipal operation of the slaughterhouse: A study of cleaner production processes within chosen municipal slaughterhouse facilities was conducted in order to propose a comprehensive environmental strategy for the processes, products and services and to increase efficiency and reduce risks to humans and the environment. This allows us to improve environmental performance and competitiveness of a slaughterhouse through the prevention and minimization of environmental pollution.
2. - Design and construction of a prototype wastewater treatment unit with a capacity of 1.5 m^3/day, for a demonstration operation in a municipal slaughterhouse: Characterization and treatability testing of the wastewater were carried out. Based on those results, the prototype was conceptualized, designed and built. This proposed technology for the treatment of wastewater is efficient, robust, sustainable and easy to transfer.
3. - Development of an Environmental Impact Assessment: This document provides an environmental study to identify current environmental impacts of the implementation of the project.
4. - Development of a Business Plan comparing the traditional and the proposed new alternative: The Business Plan is a single document that brings together all the information needed to evaluate the project and the general guidelines to implement it. This plan is essential to seek funding, partners or investors, and serves as a guide for those who will be leading the technology transfer to other municipal slaughterhouses.
5. - Preparation of a technological folder containing technical specifications and comparative analysis of production units: This folder is based on the results of the study of operating the municipal slaughterhouse, as well as those obtained from treatment of wastewater in the prototype. Also it contains the technical specifications and operating manual of the prototype.

Discussion and Conclusions

The problem posed by slaughterhouses due to their increasing abundance and the implications on environmental pollution problems and depletion of natural resources

makes it essential to seek ways to improve management from the standpoint of environmental and social aspects. In environmental management, the highest priority in the hierarchy of the integrated management of solid and liquid waste reduction is that of the origin. This leads to reducing the amount and / or toxicity of waste generated. The second priority is that of recycling, which involves the separation and collection of waste materials and the preparation of these for reuse, processing and transformation into new products. Finally there is the processing of waste, which involves physical, chemical or biological alteration. Typically, these transformations are used to improve the efficiency of operations and waste management systems, recover reusable and recyclable materials and recover conversion products (compost) and energy as heat and biogas. The community and the markets are demanding the establishment of processes and practices that preserve natural resources and the environment, ensuring a supply of clean consumer goods for present and future generations. That is why the implementation of comprehensive projects for the operation of slaughterhouses and the installation and operation of self-sustainable and environmentally friendly waste treatment is now not only a necessity, but also an imminent opportunity. This project will not only contribute to solving the problems caused by the mishandling and improper disposal of organic waste generated within the slaughterhouses, but also lead to the generation of a renewable energy source, which can be used in the same process. This will reduce emissions of greenhouse gases into the atmosphere in addition to greatly decreasing the damage to soil and aquatic systems.

References

Alvarez R. (2004). *Anaerobic Biogas Production - using anaerobic process residues*. Monograph. Universidad Mayor de San Andres. Bolivia.

Castañeda B., Castillo R. (2007). 'Treatment and utilization of waste generated in the meat industry'. *Research Association for Appropriate Technologies S.C.*

Montes de Oca, Raul. 'Environmental monitoring, from: Course of solid waste management in health facilities', *CEPIS Publications*. November 1996.

Flores Juarez C. R. (2008). 'Treatment of solid waste from slaughterhouses by anaerobic digestion'. Master's thesis. Center of Research and Technological Development in Electrochemistry.

Giraldo E. (1998). 'Mathematical modeling of anaerobic digestion process for treating industrial wastewater'. Master's thesis. Center for Research in Environmental Engineering. Universidad de los Andes. Bogotá Colombia.

Gutierrez Salazar G. and Ibargüengoytia Cuaron JA. *Use of Animal Waste in Mexico*, Chapter 8, CENIFMA-INIFAP, Queretaro, Mexico

INEGI (2009a). *'Gross domestic product in Mexico during the fourth quarter of 2008'*. Release no. 045/09. www.indetec.gob.mx/eFinanciero/Boletin140/pib% 20inegi.pdf 204trim08%.

INEGI (2009b). *Statistics cattle slaughter municipal slaughterhouses by state during 2003-2008.*

Koenig and W.C. Yiu, 1999. 'Waste Management in Hong Kong abattoirs'. *Wat. Sci Tech*, Vol 40, No. 1, pp.379-389.

LGPGIR, (2007). *General Law for the Prevention and Management of Waste. Title III.* Article 9.

Mandujano M. J. (1981). 'Biogas and fertilizer from organic waste. Manual for the developer of the technology'. *Latin American Energy Organization,* Cuernavaca, Mor., Mexico.

Marquez-Sanchez I., R. Garcia-Mata, G. Garcia-Delgado, J. Mora-Flores and Lopez-Lopez E. (2004). 'The effect of imports of beef in the Mexican domestic market, 1991-2001'. *Agrociencia* Vol 38, No. 1, January-February 2004.

Perez Zamora, O., *Ensayos en Agrociencia,* 36:279-290, 2002.

Risk Atlas of Guanajuato, 2001, vol. health risk.

Secretary of Energy (SENER). Available at www.sener.gob.mx

Sosa R., R. Chao and J. River. 'Biochemical and technological aspects of agricultural waste treatment with biogas production'. *Swine Research Institute,* Postal Drawer 1 Punta Brava 19200, C. Havana, Cuba.

Suarez-Dominguez H. and Lopez-Tirado Q., 'The beef cattle producer in Mexico. Current situation. Department of Animal Science University of Chapingo Chapingo 56230, Mexico.

Table 1. Sources of waste generation within the slaughterhouse.

PROCESS	GENERATED WASTE
Stockyards	Dead animals, manure, straw and fodder
Killing (exsanguination)	Blood
Removal of skin (skinning)	Blood, hair
Meat inspection	Rejected meat
Channel management	Cutting waste, pieces of meat, fat
Management of viscera	Stomach or intestinal contents
General Cleaning	Pieces of flesh, blood clots
Tanning	Wastewater with high salt content
Services (offices, toilets)	Waste paper, household waste, waste water