A CHANGING STRATEGY: FROM WATER RECYCLING TO METHANE BURNING. A MEXICAN EXPERIENCE

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1 INTRODUCTION

In the past five years, livestock waste treatment in Mexico has shifted from a strategy focused on water quality improvement and recycling, to another whose objective is the capture and burning of methane.

Water pollution is a major environmental problem in Mexico. Based on the Biological Oxygen Demand (BOD), in 2006, 23% of sites under monitoring reported that water was polluted and/or heavily polluted. Previously, in order to improve water quality and to make its recycling possible, in 1996 a standard on wastewater discharges was issued. With the exception of pig farming (Perez, 2006), this standard has not been assessed, nor has it been reviewed; thus, compliance and enforcement of this standard in the livestock sector is minimal. In part, this problem can be explained because the standard is not linked to, and supported by programs concerning education, technical assistance and financing, which would facilitate its compliance.

In the other hand, the emission of Green House Gases (GHGs) is a global problem in which Mexican livestock has a limited responsibility, but for which external founding is available, while no support –international or national- is focused on water quality improvement, a national and local problem that has negative effects on human health, biodiversity and economic development.

The aim of this document are: 1) To show the dimension of two environmental problems in Mexico: water pollution and GHGs; 2) To discuss the characteristics and results of the water quality control strategy in the livestock sector; 3) To analyze the new strategy of methane capture and burning in the livestock sector and 4) To discuss the environmental implications of both strategies.

2 MATERIALS AND METHODS

This work was based on the documental analysis of the National Inventory of Green House Gasses Emissions 1990-2002, the Mexican Official Standard- 001-SEMARNAT on wastewater discharges and the United Nations Framework for Climate Change Convention. Internet pages on the topic were reviewed.

3 RESULTS AND DISCUSSION

3.1 Water pollution in Mexico

Water pollution is a major environmental problem in Mexico. The National Commission of Water (NCW), the institution in charge of water monitoring, has been systematically analyzing main water bodies since 1973. In 2004, the NCW had 964 monitoring stations across the country. In that year, biological monitoring began in six of thirteen hydrological regions. Based on the Water Quality Index, in 2001 the NCW reported that 74% of the monitoring stations presented some level of contamination in water bodies; 1% had found toxics and in only 26% the quality of the water was acceptable (www.semarnat.gob.mx). One year later, in 2002, the NCW changed its methodology and nowadays information on water quality (Table 1) is based on only two parameters: Biological Oxygen Demand (BOD) and chemical oxygen demand (COD).

TABLE 1 **Monitoring Stations of Superficial Water Quality, 2006 (%)**

Quality	BOD	COD	TSS
Excellent	40.4	19.6	45.3
Good quality	25.3	18.9	33.0
Acceptable	17.6	23.8	14.0
Polluted and strongly polluted	23.0	37.8	

Source: SEMARNAT, National Commission of Water. Statistics of Water in Mexico 2007
BOD: Biological Oxygen Demand; COD: Chemical Oxygen Demand; TSS: Total Suspended Solids

This change in methodology does not allow for the comparison of data for a long period or the evaluation of whether the reduction in the percentage of stations that report pollution in water bodies is due to a real improvement in the quality of the resource or to the change in the monitoring method. Furthermore, in Mexico, there is no official information about the sources of water impairment, but in developed countries, where point pollution is under control, it is estimated that agriculture is responsible for 80% of water pollution.

According to the information of the NCW, Mexican agriculture uses 78% of extracted fresh water (livestock uses only 2%, without considering the water used in feed crops and pastures) and is one of the activities that produce the most polluting discharges: 3.2 cubic meters per second and 1,063 million tons per year of organic material[1]. Pig wastewater contains about 9,000 mg/L of BOD. International agencies have considered Mexico among the countries where the risk of water contamination by nitrogen from pig wastes is low on the national scale, but is high at the regional level, positioning Mexico in the category of countries with an overall higher risk (OECD, 2003). One of the main problems of water pollution in Mexico is the lack of information about sources of pollution and specific pollutants.

3.2 Greenhouse Gases Emissions (GHGs) in Mexico

In general, Mexico does not have direct measures of GHGs emitted by fixed and area sources, so default emission factors of the International Panel for Climate Change (IPCC) are used as parameters, given that no emission factors specific for the country or the region are available. The total emissions of GHGSs in Mexico in 2002 were 553,329 Gg. representing 2% of global emissions (Table 2).

Uncertainty was estimated based on the level 1 methodology of the IPCC's Good Practices Guidelines. Values of uncertainty associated to annual emissions estimations and their trend were calculated. According to this approach, it is estimated that the National Emissions Inventory of GHGs for 2002 has a global combined uncertainty of 7% and 4% for uncertainty in the trends of emissions.

TABLE 2 **Emissions of GHGs in Gg in CO_2 equivalent, 1990 and 2002**

Category of emission	1990	2002	% 1990-2002
1 Energy	312.027.2	389.496.7	+24.8
1A Fossil Fuels Consumption	*279.863.7*	*350.414.3*	*+25.5*
1B Fugitive Emissions	*32.163.5*	*39.082.3*	*+21.5*
2 Industrial Processes	32.456.4	52.102.2	+60.5
4 Agriculture	47.427.5	46.146.2	- 2.7
6 Residues	33.357.2	65.584.4	+133.5
Total	**425.268.2**	**553.329.4**	**+5.3**

Source: SEMARNAT, INE, 2006

In 2002, agriculture generated 46,146 Gg of equivalent CO_2 including methane and nitrous oxide. Reductions in GHGs emissions in the period of 1990-2002, could be attributed to the decrease in the areas cultivated with rice, one of the key sources of GHGs emissions in agriculture.

Depending on the year, the number of sources contributing with more than 95% of the tendency of the inventory changes range between 13 and 15 from 1990 to 2002. Important categories in that period are electricity,

[1] Only sugar cane industry and oil industries have more polluted discharges with 1,750 M tons/year and 1.186 M tons/year, respectively (NCW, 2003)

the manufacture and construction industry. Enteric fermentation occupies the fourth place during this period. This distribution may significantly change if changes in land use are included (Table 3).

Livestock is considered a key source of GHGs emissions; during 2002, the livestock sector contributed with 38,527.55 Gg (83% of the agricultural sector). Average methane emissions (the sum of enteric fermentation and manure management) in the 1990-2002 period were 1,823 Gg (37,366.87 Gg CO_2e) of which cattle emissions represented 89%, dairy 10% and the remaining 1% the rest of farm animals (SEMARNAT, INE, 2006). Considering only waste treatment (no manure applications as fertilizer or manure generated in grazing) estimated emissions of nitrous oxide were about 0.02 Gg.

Emission factors from dairy cattle were equivalent to those in developed countries, while the reported factor for meat cattle was slightly lower to the default factor suggested for Latin American countries. The emission factor for anaerobic fermentation of cattle wastes is a weighted average taken from Gonzalez-Avalos and Ruiz-Suarez (2001). In a recent paper (Gonzalez-Avalos and Ruiz-Suarez, 2007), these authors find that the methane emission factor from cattle manure was smaller, on the average, by at least a factor of five than the one proposed by the IPCC for Latin America. It is important to point out that the maximum methane production is obtained in anaerobic lagoons, followed by slurry management systems and both systems for cattle manure management are almost non-existent in Mexico. These systems do exist for pig manure, but they were not included in the national inventory. Enteric fermentation presented a high value of uncertainty in the trend in 2002 due to uncertainty in the data of the activity (stocks, emissions, technologies, etc.). A default value of 20% of global uncertainty was suggested to use.

TABLE 3 **Evaluation of key sources for trend in 2002**

Source Category IPCC		**Sector**	**GHGSs Direct effect**	**CO_2 eq. Estimation** Gg	**Contribution to the tendency** %
1A1a	Electricity	Energy	CO_2	115.449.087	21.19%
1A2	Manufacturing and construction industry	Energy	CO_2	51.025.368	16.74%
6A	Solid waste disposal on land	Residues	CH_4	34.960.611	10.18%
4A	Enteric fermentation	Agriculture	CH_4	37.366.876	9.70%
1A1b	Oil refinery	Energy	CO_2	37.020.277	9.17%
2A	Minery products	Industrial Processes	CO_2	30.618.698	7.83%
6B	Wastewater management And treatment	Residues	CH_4	28.566.615	6.24%
	Residential	Energy	CO_2	19.277.118	3 .39%
4D	Agricultural soils	Agriculture	N_2O	7.449.319	1.32%

Source: SEMARNAT, INE, 2006

3.3 Characteristics and results of the water quality control strategy in the livestock sector

In order to protect the quality of national waters, prevent their deterioration and enable the re-use of water, the Mexican Official Standard 001-SEMARNAT-1996 (MOS 001) was published in January 1997. The MOS 001 establishes maximum permissible limits (MPL) for 20 pollutants[2] in wastewater discharges to national waters for all the activities in terms of two elements: the type of receptor body and the subsequent use of the water. The government decided that by controlling the discharges of the biggest polluters, only a few big companies in the livestock sector, the pollution of water bodies would be significantly reduced in the short term. Hence, the government offered a 3-stage compliance schedule: January of 2000, 2005 and 2010 for big polluters (more than 3.0 tons/day of BOD or TSS), medium polluters (from 1.2 to 3.0 tons/day BOD or TSS) and small polluters (less

[2] Fecal coliforms, pH, helmynth eggs, temperature, grease and oils, floating material, sedimentable solids, total suspended solids, biochemical oxygen demand, nitrogen, phosphorus, arsenic, cadmium, cyanide, copper, mercury, chromium, nickel, lead and zinc.

than 1.2 tons/day BOD or TSS) respectively. A few issues regarding the implementation of this standard are addressed:

The implementation of a standard requires a wide process of consultation and a cost-benefit analysis (C/B) showing its economic viability. The C/B analysis of the MOS 001 (Rojas *et al.*, 1997) estimated that the economic viability of the standard requires a secondary treatment technology.

With the exception of pig farming (Perez, 2006), this standard has not been assessed, nor has it been reviewed; compliance and enforcement of the standard in the livestock sector is minimal, while the assessment of the MOS 001 in the pig sector concludes:

- It is not economically viable because pig farms need tertiary treatment in order to avoid surpassing the maximum permissible limits of the pollutants allowed by the standard.
- Its surveillance by authorities is minimal because it is costly.
- Water analyses are costly and their results do not represent a fair basis upon which to charge fees. The results of a wastewater sample (measured in concentrations) are inappropriate in activities subject to the uncertainties of nature.
- MOS 001 is a regressive mechanism because small pig producers pay more than medium and large producers. It is also unfair because it is more expensive for pig production than for other industries.
- The regulatory approach, exemplified by Standard 001, is useful in countries where it is supported by subsidies, financing and other economic instruments designed to facilitate compliance and where institutions are able to enforce compliance.

3.4 Characteristics of the new strategy of methane capture and burning in the livestock sector

In order to reduce atmospheric emissions of methane generated by the livestock sector, some actions funded by the Clean Development Mechanism (CDM *cap and trade*) under the Kyoto Protocol, have been carried out in order to capture and burn methane. The CDM of the Kyoto Protocol allows industrialized countries (the so-called Annex 1 countries) with a GHGs reduction commitment, to invest in emission reducing projects in developing countries and count them towards their Kyoto targets.

The GHGs reduction project in Mexico is the installation of a biogas control system that captures and destroys methane gas from manure treatment and/or storage facilities on livestock operations. Regardless of how the project developers take advantage of the captured biogas, the ultimate fate of the methane must be destruction. Activities not associated with installing a biogas control system do not meet the definition of the GHGs reduction project. Furthermore, producing power for the electricity grid (and thus displacing fossil-fueled power plant GHGs emissions) is a complementary and separate GHGs project activity and it is not included within projects in Mexico. Additionally, project developers should demonstrate that the project meets local air and water regulations; in this regard, projects that do not comply with air and water quality regulations should not be eligible to register GHGs reductions.

Since December 2005, 89 Animal Waste Methane Recovery projects were registered in the UNCFFF page, 21 large projects and 68 small with 1,355,666 and 875,681 metric tonnes of CO_2e per annum of estimated emission reductions, respectively. Four of them classified as Methane Recovery and Electricity Generation projects. The total amount of metric tonnes of CO_2e per annum is 2,231,347 metric tonnes. If these reductions were really possible, Mexico would be diminishing 56.5% of the annual emissions of CO_2 attributed to the livestock sector (3,943,149 metric tonnes of CO_2[3]). Installation of the biogas manure biogas control system, and the measurement and monitoring of GHGs reductions are in hands of the project developer, who receives the Certificates of Emissions Reductions based in a contractual agreement between private agents. Updated information from the UNFCC (22/02/2010) shows that from the 89 registered projects, only 21 (some of them involving several farms) have received CER's amounting 795,405. That means that 795,405 tonnes of CO_2 emissions have been avoided.

4 CONCLUSIONS

Mexico faces a problem of lack of accurate information on two environmental problems: water pollution and the generation of GHGs. With partial and unreliable information, a standard on wastewater discharges and an inventory of GHGs have been issued. Studies show that the livestock sector (particularly the Concentrated Animal Feeding

[3] 1.823 CH_4 Gg emission*103=187.769 CH_4 metric tonnes*21= 3.943.149 CO_2 metric tonnes

Operations), are a key sector in water pollution and in the generation of methane. The economic problems of the livestock sector, structural and emerging (the AH1V1 virus emergency and its impact on pig production), have relegated the implementation of the standard on wastewater discharges. The MOS 001 is not linked to economic incentives nor to technical assistance that would facilitate its compliance. In contrast, the Clean Development Mechanism, through project developers, offers a comprehensive technology package in which there is no participation of the producer. The effluent after the biodigestor cannot meet the Mexican Official Standard-001 on wastewater discharges (from 30 to 200 mg/lt BOD according to the receptor body) and it might be difficult to treat further since it is completely anaerobic and thus would lack organic nutrients for aerobic bacteria which are the only ones that can reduce the BOD to national standards. The technology in use, while mitigating environmental problems, leaves unresolved the country's fundamental problem which is water pollution and not GHGs emissions.

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