Management of municipal water and sanitation in Latin America and the Caribbean with a climate change perspective. Project approaches

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Abstract

Climate change is recognized as one of the more serious potential threats to the environment. Municipal wastes are significant contributors to greenhouse gases emissions through decomposition and life-cycle activities processes. Wastewater management has not been yet seriously considered as potential part of the Clean Development Mechanism (CDM) projects. A reason is a matter of scale and mass of organic carbon involved. However, the number of facilities is very high, and their added contributions represent an important source of greenhouse gases (GHG).

There is an opportunity to identify wastewater treatment technologies processes that may have low carbon footprints in order to contribute for mitigating the climate change impacts of the Latin American and Caribbean (LAC) region. Moreover, the lack of treatment infrastructure in the region is an opportunity for choosing more sustainable technologies when deciding the construction of new treatment facilities.

This research project evaluates the state of LAC wastewater systems and also explores possibilities to identify alternatives for more effective and sustainable wastewater treatment, based on Life Cycle Assessment (LCA) methodology.

Keywords: Wastewater, Climate change, Life Cycle Assessment

Introduction

In order to significantly increase health and wellbeing in developing countries and the poorest areas of the world, the Millennium Development Goals (MDG) has been promulgated by the General Assembly of United Nations (UN, 2000). Basic sanitation in LAC, even if it is relatively generalized in the region (78%) compared with other mid or low income countries, it is still behind in suitable infrastructure: 29% has latrines or septic tanks and centralized sewage systems cover 49% of the population (OPS, 2001). Moreover, sewage treatment is still very limited, estimating that only 15% of the collected wastewaters are actually treated. This is a clear indicator of the enormous need for investment in this area and the lack of adapted treatment processes.

The challenge to provide better health and life conditions to all inhabitants of developing countries must be faced with innovative solutions based on a clear understanding of the specific context of the LAC region. In order to develop and to apply solutions to the infrastructure deficit for LAC wastewater management, new management and technological systems will have to consider the limitations and capabilities of the region, considering a high dose of innovation and adaptation, defining alternative solutions to the conventional ones in many cases. For this purpose, the Life Cycle Assessment (LCA) methodology has been used to explore the sustainability of wastewater systems and their design, with different technical solutions (Lundin *et al.*, 2000; Machado *et al.*, 2007).

This research project aims to solve basic issues related to evaluate the state of LAC wastewater systems and explore possibilities to identify alternatives for more effective and sustainable wastewater treatment as well as new ways of energy production based on these processes. In order to identify the potential environmental impacts generated by the different wastewater treatments systems, as a basic input for decision makers, the LCA methodology, will be used. In addition, new approaches that incorporate not only environmental, economic, technological and institutional factors but also social aspects in order to secure the feasibility of the whole system from a holistic perspective will be identified and discussed.

The International Development Research Center (IDRC) of Canada has signed an agreement with the Institute of Engineering at the National Autonomous University of Mexico (II-UNAM) to develop this project.

Overview of the problem

Climate change is recognized as one of the bigger and more serious potential threats to the environment and there is an urgency to put forward actions to reduce GHG emissions very soon (Tilche and Galatola, 2008). Climate is strongly influenced by changes in atmospheric concentrations of greenhouse gases (GHG) such as CO_2, CH_4, N_2O, among others, and municipal wastes are significant contributors to GHG emissions through decomposition and life-cycle activities processes.

Wastewater management has not been yet seriously considered as potential part of the CDM projects. Sewage is rather diluted in terms of organic matter concentration, so the amount of carbon dioxide or methane that may be produced is much lower compared with municipal solid waste. However, the number of facilities is very high, and their added contributions represent an important source of GHG that should be controlled.

The diversity of technological options available at the present time makes the selection of the most suited wastewater treatment solution a difficult task. It may be considered that the best treatment scheme will be the one that minimizes cost as well as complexity, achieving the required water quality, either for final disposal or for reuse, without affecting the availability and quality of water of future generations as well as of the natural resource. The concept, apparently obvious, has not been applied in a good number of occasions, which has led to the abandonment of many facilities for sewage treatment in developing countries, caused by high operation and maintenance costs. Also, in many times, systems have been chosen based on short term political criteria without considering the input of the operator organism or the population served.

Goals and expected results

Considering the wastewater treatment facilities contribute to the GHG emissions and they should be reduced, it is strongly needed to study the adequate ways to mitigate this effect. The research project goals are as follows:

-To determine state of the art in wastewater treatment related to the LAC region and particularly in the following countries: Brazil, Colombia, Chile, Guatemala, Mexico and Dominican Republic.

-To develop conceptual engineering design related to mass balances and life cycle assessment for the identified most widely wastewater treatment technologies used in LAC.

-To identify and recommend the technical, economical, social and environmental most appropriated technologies for wastewater treatment in LAC, and to evaluate their feasibility to develop CDM projects, based on CDM base line methodologies according to the United Nations Framework Convention on Climate Change sector scopes (waste handling and disposal).

-To establish general technical guidelines for the definition of wastewater process in terms of reducing GHG emissions. Also, contribute to the generation of clean energy at municipal level and to encourage regional development and implementation of new, more sustainable technologies.

-To identify research opportunities for wastewater treatment processes improvement based on reduction of their GHG emissions.

Current status of project

In order to carry out the mentioned goals, the project has been divided in three main stages and these are outlined below:

1. The information obtained from wastewater plants in LAC was collected from the official agencies through a consulting engineer in each selected country. Special spreadsheets were designed to be filled out. Questions related to the operation and design wastewater treatment plants in technical, environmental and economic aspects were included. It should be mentioned that the information collected was only a sample out of wastewater treatment plants in each selected country.

2. A conceptual engineering analysis with elements of basic engineering was realized for the three most used treatment technologies in the region. With this information, life cycle assessment studies are being performed for each identified process, according to the wastewater quality (Figure 1).

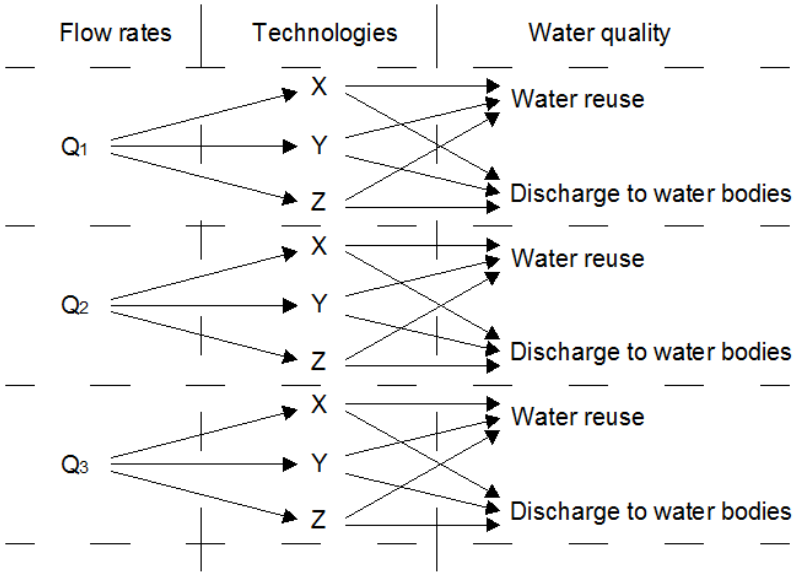

Figure 1. Evaluated scenarios in function of flow rate, technologies and water quality.

Figure 1 presents a schema of the 18 different scenarios that were established from the information collected by selecting the three most used technologies according to the three most common flow rates and the treated water quality. In each scenario, mass balances were realized, in which all the streams involved in the processes (including liquid, solid and gas) were characterized. Energy requirements were determined as well. Also preliminary sizing, equipment, civil works, mechanical piping, electrical works, system instrumentation and control were estimated. Finally, the estimated investment and operating costs, based on input data such as flow rate, water quality and kind of technology were calculated. In order to compute these results, a process simulator was developed for this project. The information obtained from the process simulator will feed the inventory for the LCA study, which it will be completed with more information obtained from field trips to different wastewater treatment plants in each selected country.

In order to have sufficient evidence to recommend the most appropriate technologies, there will be a comparison of the results of LCA study for the three kind of treatment in the 18 scenarios configured to analyze the environmental and social impact of the different technologies

The social aspects to be considered in the evaluation are still under definition, considering that at this moment, the related methodological tool is emerging in Europe. In order to explore possible collaborations that allow a first approach to the subject, nowadays the II-UNAM is seeking support with the Institute of Social Sciences at the National Autonomous University of Mexico

3. Identify and recommend the most appropriated technologies for wastewater treatment in LAC, in function of flow rate and quality of the treated wastewater according to the results of the LCA study.

At this stage we will explore possibilities to identify the more effective and sustainable options for wastewater treatment in terms of reduction environmental impact, cost and improved regional development. The outcomes will be in the technical guidelines for selecting wastewater treatment processes in small, medium and large towns for LAC region.

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References

Lundin, M., Bengtsson, M. and Molander, S. (2000). Life cycle assessment of wastewater systems: Influence of system boundaries and scale on calculated environmental loads. Environ. Sci. Technol. Vol. 34. pp 180-186.

Machado A.P., Urbano,L., Brito, A.G., Janknecht, P., Salas, J.J. and Nogueira, R. (2007). Life cycle assessment of wastewater treatment options for small and decentralized communities. Water Science and Technology, Vol. 56. No 3. pp 15–22.

OPS (2001) Informe Regional sobre la Evaluación 2000 en la Región de las Américas, Organización Panamericana de la Salud, Washington D.C. 81 pp. Disponible en: www.bvsde.ops-oms.org/bvsaas/e/fulltext/infregio/infregio.pdf

Tilche, A. and Galatola, M. (2008). The potential of bio-methane as bio-fuel/bio-energy for reducing greenhouse gas emissions: a qualitative assessment for Europe in a life cycle perspective. Water Science and Technology, Vol. 57. No 11. pp 1683-1692.

United Nations (2000). Goal 7. Ensure environmental sustainability. United Nations Millennium Goals. http://www.un.org/millenniumgoals/