A Comparison of Two Wastewater Treatment Plants: Stabilization ponds and Activated Sludge with a Social perspective impacts.

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Abstract This paper presents an environmental study and a social evaluation aproach of two wastewater treatment plants (Activated Sludge System, and Stabilization Ponds, designed for an avarage of 15 l/s). The environmental and social assessment of these Waste Water Treatment Plants (WWTPs) has been realized by means of the Life Cycle Assessment (LCA) technique, in order to establish with a broad perspective and objective way the technology that provokes the lowest environmental load and to identify the technology wich contributes to the social development, offering a wide vision for the decision makers. The results show that a greater number of environmental impacts are generated by the activated sludge; however, from a social approach the impacts associated with this technology have a better performance.

1 Introduction

In the big cities like Mexico City, wastewater has become an inevitable issue, because the amounts are generated daily by population; the infrastructure that is considered for treatment, the environmental impacts of processes and social impacts which involves the management of these technologies.

This study compare two technologies of Wastewater Treatment: Stabilization Ponds and Activated Sludge, with the intention of assessing the environmental impacts incurred in each technologies evaluated and their threads; within the assessment considers the building site, equipment manufacturing, operation and open dump. Similarly outweighs analyzed from the perspective of the social impacts at the LCA generated by the management of Water Treatment Plants

(WWTP), considering as key stakeholders to: the society, the local community, the work class people, the value chain and the government who is, in this case, the manager of technology management. The two WWTPs evaluated are classified as small plants because they treat an avarage of 15 l/s, considering a lifetime of 20 years.

2 Metodology

For this assessment the environmental impacts were evaluated as the following categories: Air Acidification (AA), Aquatic toxicity (AT), Depletion of Stratospheric ozone (DSO), Depletion of abiotic resources (DAR), Eutrophication (EU), Greenhouse effect (direct, 100 years) (GEI), Human Toxicity (HT), Photo-oxidants formation (POF) and Terrestrial Toxicity (TT) according to the CML2000 models.

The functional unit chosen was the total amount of treated water during a period of time of 20 years, which was considered as the lifespan of WWTP, being 11,352,960 m3 in 20 years to LE and 7,568,640 m3 in 20 years to LA. This study considered the next subsystems: building site (OC), equipment manufacturing (FE), operation (OP) and open dump (VRTD). The raw materials extraction, cement fabrication and the electricity generation are adopted from the DEAM database (associated to the TEAM 4.0 software) considering the USA Electricity mix; final disposal of WWTP was not considered. All the data related with the operation stage were proportionate directly by the WWTP operators, while construction, the equipment fabrication and transport were estimated according to scientific reports.

The Stabilization Ponds technology (PTARLE), has a treatment capacity of 18 l/s and a total area of 50,000 m^2, and considers the primary and secondary treatments; this study include the process of dry sludge.

The Activated Sludge technology (PTARLA) has a treatment capacity of 12 l/s, and an area of 2,800 m^2, considering three treatment process: primary, secondary and tertiary process. The digested sludge is discharged to drain. Both wastewater treatment assessed include the process described at Table 1.

For the social study were considered to stakeholders such as workers, employees of each plant; as consumers, buyers of treated water and dry sludge; as the supply chain (supply chain actors) to material suppliers; as local community is considered the municipality where the plant is installed, and as a Society the state of Mexico where they belong. Both plants are operated by local governments. Impact categories selected for study are: Human rights (HR), Working conditions (WC), Health and safety (HS) and Socio-economic repercussions (SR). In order to gather information interviews were applied to the stakeholders and public data were collected.

The aim of this work is to evaluate the environmental performance of two WWTPs and to know wich of them contribute to the sustainable development.

Tab.1: Unitary processes for the two technologies analyzed

PTARLA		PETARLE	
01_PRE	Pre-treatment	1_PRE	Pre-treatment
02_CB	Pump operation (cb)	2_CB	Pump operation (cb)
03_TQP	Primary Treatment Tank	3_BDG	Bio digester
03a_SP	Blowers	4_LGA	Anaerobic Ponds
04_RB	Bioreactor	5_LGF	Facultative Ponds
05_TQS	Secondary Treatment Tank	6_LGM	Maturation Ponds
06 DL	Sludge Digester	7_LCH	Dewater sludge
07_TQC	Chlorination Tank		
8_CBAT	Cb Treated Water		
9_CBPG	Cb Purges		

3 Results and discussion

3.1 Impactos ambientales

3.1.1 Air Acidification

Figure 1 shows that the PTARLA has a greater impact on air acidification, which is mainly due to SO_x and NO_x, assuming they are produced by electricity generation, which is consumed in the operation of the equipment. This is consistent with that reported by Tillman et al. (1998), Lundin et al. (2000), Hospido and Moreira (2008), who indicated that the greatest impact of acidification emissions are caused by the production of electricity.

3.1.2 Aquatic toxicity

Figure 2 shows that PTARLA has a greater impact in the aquatic toxicity because the influent water contains metals such as cadmium and copper mainly**.** These two types of biological processes of wastewater treatment are not specific for the removal of metals, therefore, water quality in the input and output maintains the same levels of metals.

3.1.3 Stratosphic ozone depletion

Figure 3 shows that the PTARLA has the greatest impact, which is generated by solid waste collection in the pre-treatment process, these wastes are transported and disposed of an open dump; in the open dump due to waste composition, climatic conditions, the waste management and its descomposition generate the CFC_{11} and CFC_{12}, which decreases stratospheric ozone and contributes to the ozone layer depletion.

3.1.4 Depletion of abiotic resources

It is assumed that this impact is generated by the energy mix used to produce electrical energy, fossil fuels such as coal, oil and Natural Gas generate the major impact. The impact indicator for this category is related to the extraction of minerals and fossil fuels, based on the remaining reserves and extraction rates.

3.1.5 Eutrophication

Eutrophication is one of the priority criteria for the definition of sustainable wastewater treatments, Hellström et al. (2000). As can be seen in Figure 5, the discharges of phosphorus in the treated water was the most relevant factor contributing to eutrophication (Gallego et al. 2008) in the PTARLE.

The PTARLA's contribution is due to the discharge of digested sludge to sewage and treated water, with a high content of phosphorus and phosphates.

These biological processes (activated sludge and stabilization ponds) remove only between 10 to 30 percent of the phosphorus and phosphate present in wastewater (Metcalf & Eddy, Inc., 1996).

3.1.6 Greenhouse Gasses

Figure 6 shows that the PTARLE has the greatest potential impact for emissions of greenhouse gases are largely to the impoundment process (mainly anaerobic ponds).

The process of stabilization ponds, produce higher emissions to the environmental as a result from the process itself. A. Gallego, (2008), because it generates greenhouse gases (GHGs), such as CH_4, N_2O de CO_2, this is consistent with all the reported by Zambrano et al. (2007). In general when the process is evaluating the emissions generated by the process itself, the system of stabilization ponds has a high global warming potential greater than the activated sludge system.

3.1.7 Human Toxicity:

Figure 7, the PTARLA has a greater impact due to emissions of certain toxic substances.

With these results, it is determined that according to the energy mix and emissions generated in the electricity generation , there are such chemicals; as arsenic (As), hydrogen fluoride (HF), Nickel (Ni) and Benzene (C_6H_6) which pollute the air and substances are highly toxic to humans.

3.1.8 Photo-oxidants formation

Figure 8 shows that PTARLE contributes mainly to the formation of photo-oxidants, due to methane gas (CH_4) produced in anaerobic ponds. In the case of PTARLA the impact is associated to equipment operation and energy consumption, caused by Carbon Monoxide (CO), Etilene (C_2H_4) and Methane (CH_4).

These chemicals cause the formation of photo-oxidants, the presence of light and nitrogen oxides promote the formation of tropospheric ozone. While the emission of methane (CH_4) causes the greatest impact.

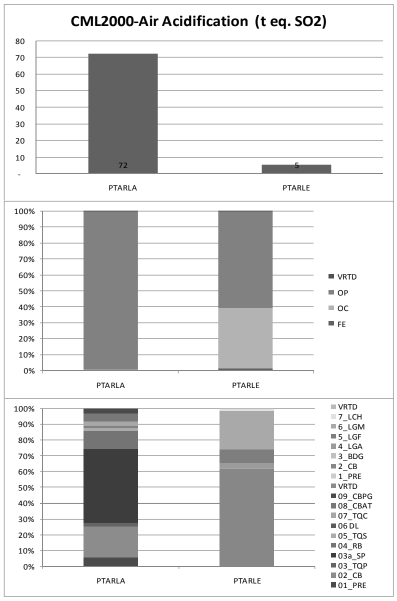


Fig. 1. Environmental impacts associated to the two technologies.

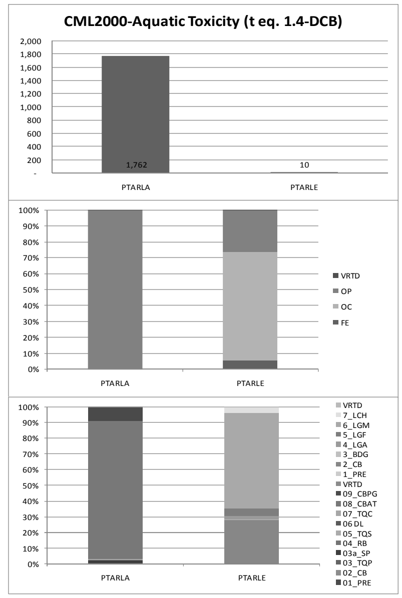


Fig. 2. Environmental impacts associated to the two technologies.

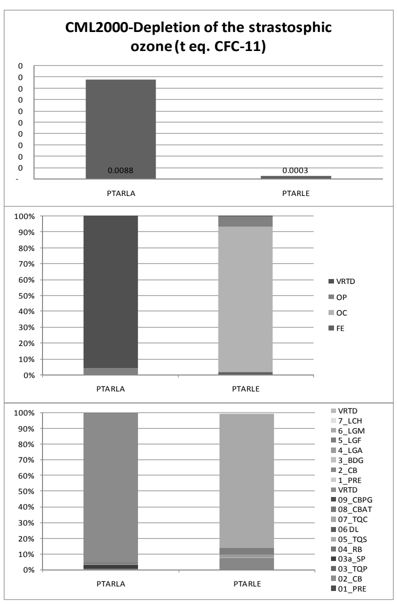
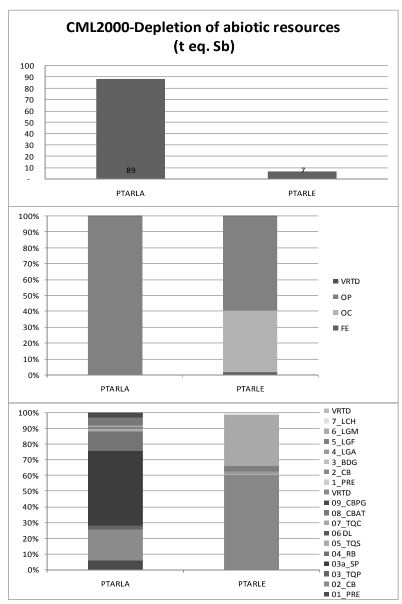


Fig3. Environmental impacts associated to the two technologies.



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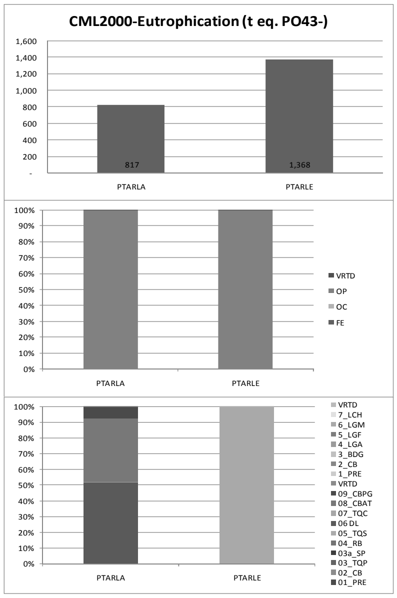

Fig.5. Environmental impacts associated to the two technologies.

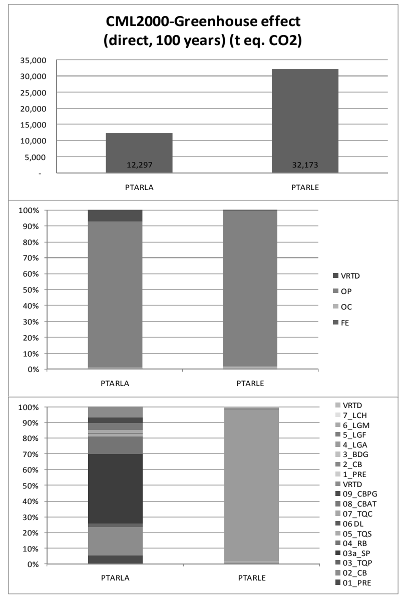

Fig.6. Environmental impacts associated to the two technologies.

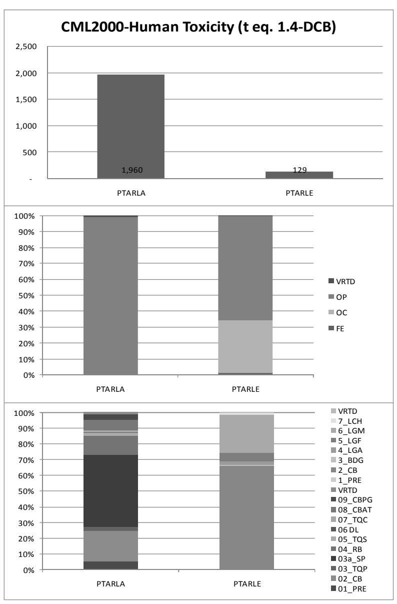

Fig.7. Environmental impacts associated to the two technologies.

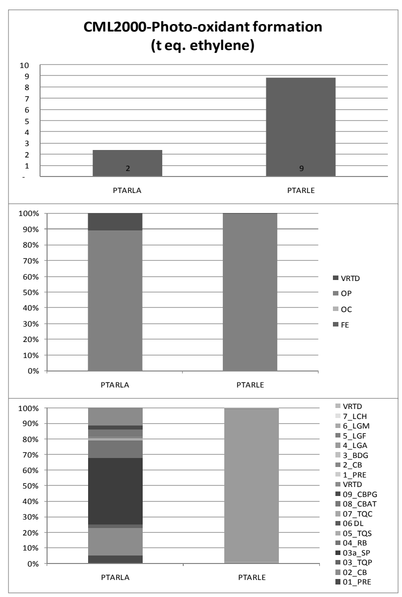

Fig.8. Environmental impacts associated to the two technologies.

3.2 Social Impacts

Reference values were established for social impact assessment according to each stakeholder (Workers, Consumers, Supply chain actors, Local community, Society), the categories of impact (Human rights (HR), Working conditions (WC), Health and safety (HS) and Socio-economic Repercussions (SR)), and subcategories of impact described in Figure 9.

STAKHOLDER	IMPACT SUBCATEGORIES	REFERENCE VALUE		CATEGORIES			
		POSSITIVE	NEGATIVE	HR	WC	HS	SR
Workers	freedom of association	YES	NO	☑	☑	☑	☑
	discrimination	NO	YES	☑	☑	☑	☑
	child labour	NO	YES	☑	☑	☑	☑
	fair salary	YES	NO	☑	☑	☑	☑
	working hours	<= 48 hrs.	>48 hrs.	☑	☑	☑	☑
	forced labour	NO	YES	☑	☑	☑	☑
	health and safety	YES	NO	☑	☑	☑	☑
	social benefits	YES	NO	☑	☑	☑	☑
Consumers	health & safety	YES	NO	☑	☑	☑	☑
	consumer privacy	YES	NO	☑			☑
Supply chain actors	fair competition	YES	NO				☑
	promoting social responsibility	YES	NO	☑	☑	☑	☑
Local community	net migration rate	NO	YES	☑	☑	☑	☑
	safe and healthy living conditions	YES	NO	☑	☑	☑	☑
	local employment	YES	NO	☑	☑	☑	☑
Society	contribution to economic develop	YES	NO	☑	☑	☑	☑
	technology development	YES	NO		☑	☑	☑

Fig.9. Social Impact Assessment

In Figure 10, it can be observed that the two WWTP generate positive social impacts, although there are no significant diferences, however, in a comparative analysis the PTARLA has a greater number of employees (20 people), while on the other hand PTARLE has only 4 people in the staff; also the benefits asociated to activated sludge system are greater than in stabilization ponds system.It is assumed that these social conditions are given because it is in an urban area (Mexico City) and the level of education or skills to work in these plants (activated sludge) is higher than those required in stabilization systems located in rural areas.

STAKHOLDER	IMPACT SUBCATEGORIES	PTARLA		PTARLE	
		VALUE	ASSESMENT	VALUE	ASSESMENT
Workers	freedom of association	yes	☺	yes	☺
	discrimination	no	☺	no	☺
	child labour	no	☺	no	☺
	fair salary	yes	☺	yes	☺
	working hours	48 hrs.	☺	48 hrs.	☺
	forced labour	no	😐	no	😐
	health and safety	yes	☺	yes	☺
	social benefits	yes	☺	yes	☺
Consumers	health & safety	yes	☺	yes	☺
	consumer privacy	yes	☺	yes	☺
Supply chain actors	fair competition	yes	☺	yes	☺
	promoting social responsibility	no	😐	no	😐
Local community	net migration rate	no	☺	no	☺
	safe and healthy living conditions	yes	☺	yes	☺
	local employment	yes	☺	yes	☺
Society	contribution to economic develop	no	😐	yes	☺
	technology development	no	😐	no	😐

☺	Possitive effect
😐	Indifferent effect
☹	Negative effect

Fig.10. Results of the Social Impact Assessment

4 Conclusions

In this case study, Activated Sludge technology shows better performance in the categories of Greenhouse Effect, Eutrophication and Photo-Oxidants Formations, while the Stabilization Ponds have better performance in Air Acidification, Aquatic Toxicity, depletion of the stratosphic Ozone, depletion of abiotic resources and Human Toxicity.

In the Activated sludge WWTP, the main generator of electricity impacts is due to the use of energy, therefore, the alternative to generate electricity from renewable energies may reduce the environmental impacts associated with this activity.

In Stabilization Ponds WWTP, the main generator of the environmental impacts are emissions produced in the anaerobic processes, the capture and use of those gases produced by the plant could be an alternative to reduce impacts.

None of technologies generate negative social impacts due to government management and enforcement of existing laws in Mexico, the impacts generated are positive, and more by the PTARLA by the generation of more jobs and better benefits to workers.

The results of this study indicate that wastewater treatment plants produce an environmental benefit but also generate environmental impacts associated to its life cycle.

The PTARLA generates a greater number of environmental impacts, but also is the one wich generates more social benefits, therefore it is important to consider the criteria and the circumstances in each situation to assess the purpose of selecting the technology that meets the particular needs in each case.

Further research: In Latin American Countries should considerate: Different flows and technologies, dismantling and final disposal of WWTP; take into consideration the environmental, social and economic impacts as benefits along the life cycle of WWTP.

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