Organic solid waste treatment and its deposition through sewage net. Technical and financial analysis for domiciliary treatment systems.

Willson, Victoria; Calcagno, Facundo Martín; Boeykens, Susana P.; Caracciolo, Néstor
Universidad de Buenos Aires, Facultad de Ingeniería,
Chemistry Laboratory of Heterogeneous Systems (LaQuíSiHe),
Buenos Aires, Argentina
laquisihe@fi.uba.ar

Abstract

In this work, it is intended to address the problem of Urban Solid Waste (USW) progressive generation and the decreasing spaces availability for its deposition. Based on this situation, main objective is to analyze the technical, economic and financial viability of an USW-organic-fraction-treatment home automatic and continuous system implementation, applied in Buenos Aires City, Argentina. In terms of the selected methodology, the following technical aspects are firstly studied:
- Domiciliary system (composter) analysis in its two possibilities of final result: i) deposition through sewage net, considered for apartments, ii) compost for amendment purpose, considered for houses.
- System implementation viability within Buenos Aires from studies and field measurements.
Based on the technical analysis, economic and financial study has the objective of proving the significant saving for the city government that the reduction of organic waste fraction can potentially generate. In order to obtain these results, some of the considered economic aspects are:
- Definition of the budget able to be saved.
- Costs and utility generation since the domiciliary system implementation.
- Choice of a Rate of Return to calculate the Net Present Value of the project.
Regarding the conclusions, the main one is the verification of viability of this implementation in Buenos Aires.

Keywords
Waste digestion; organic solid waste; sewage treatment plant; composting; compost production;
Solid waste economy impact; compost impact on sewage system; sanitary city issues; home waste treatment; sewage sludge; wastewater treatment plants; biosolids; amendment material.

1. Introduction

Composting plays an important role in the strategies used today for the integrated management of urban solid waste in many parts of the world. Composting is the most cost-effective way to reduce greenhouse gas emissions (Ayalon et al., 2000).
The domestic waste separation of the biodegradable fraction has been implemented on a large scale and with significant success in many European countries, USA, Canada, Australia, New Zealand and Japan. These countries currently have very high efficiency rates in terms of waste separation, and their policies are aimed to achieve a continuous improvement, promoting the compost generation at every home (De Bertoldi et al, 1998).
Domestic composting should not be seen as an alternative treatment option for all organic waste, but as a complementary solution in USW integrated management. Domestic composting provides a flexible and low-cost option, facilitating sustainable recycling. However, the active participation of a significant proportion of citizens in a given area is required for this strategy to impact the rate of diversion of waste. To this end, the municipalities had promoted various campaigns about the benefits of domestic composting (Andersen et al., 2011).
Among the secondary benefits offered by the use of these devices in the home we must emphasize that, by ceasing to dump and mix food waste with the rest of the USW, the type and quantity of them that will require urban

collection are substantially modified. Thus, it is possible to reduce by more than 40% the weight of the waste to be disposed.
Other advantages associated with the generation of compost from USW include the greater carbon, nitrogen and phosphorus fixation in its structure, the amendment and improvement of soil structure and texture, increasing its retention of moisture and physical properties, and reducing the incidence of plant diseases, favoring the substitution of the use of synthetic agrochemicals (Hargreaves et al, 2008; Martínez Blanco et al, 2009).

1.1 Problem situation

The progressive generation of USW per capita and the decreasing availability of deposition sites for them is a problem that occurs worldwide (Hoornweg et al, 2012).
Due to this growing trend, the shortage of filling space in many countries of the world is also combined with a great environmental impact and high costs of collection, treatment and deposition of waste for every government.
In particular, the organic fraction has some consequences when it remains on the streets: epidemiological vectors, contamination of recyclable fraction if there is no separation, and bad odors due to decomposition, among others.
In the attempts to stop generating garbage that goes to sanitary landfill, Buenos Aires is beginning to divide between recyclable and non-recyclable, but there is a large percentage of waste regarding the organic fraction (approximately 40%) that could be also seized.

1.2 Objectives

Given this situation, the main objective is to analyze the technical, economic and financial feasibility of the implementation of a home-treatment system for the USW organic fraction applying this study to Buenos Aires City, where this system consists in a composter designed in the Chemistry Laboratory of Heterogeneous Systems, which is original and has characteristics that differentiate it from the rest of composters offered in the market.
This will represent a possible solution for the decision-maker on USW management in Buenos Aires, proposing the use of a composter model that we take as an example of application.
To reach this objective, the project is divided at the same time into two areas of study that will be delimited by the options of disposal or final use that the result of this home composting has:
- Disposal of compost with degrading fauna by sewage, which will be assumed to be used in departments.
- Use of the resulting compost as fertilizer for the amendment of gardens, green spaces, agricultural industry, etc; which is assumed to be used in homes.

The division between these two groups has its origins in the idea that houses would be more related with the use of compost like fertilizer as they mainly have green space, whereas in a department would not have direct use. This two possibilities also differ on the way of financing and the actors involved in each alternative.

2. Methodology

2.1 Technical Analysis

The proposed composter is constituted by the following 3 chambers: i) power supply, whose volume is 54 L, ii) aerobic digestion, whose volume is 47 L, and iii) final composting, whose volume is 39 L.
Each chamber has deflector baffles, which prevent slippage in the rotation of the bioreactor and contribute to the grinding work performed by the dividing plates of the chambers.
To facilitate the removal of compost and control on the process, in the third chamber there is a damper, which presents an original design that has incorporated a shovel for the extraction of the compost at any moment.
A special filter was designed located at the lowest point of the third chamber to allow the free discharge of excess leachate and not capillary retained by the mixture.
This automatic composter is self-heated, so energy is not added to maintain the temperature and the average monthly compost generation is 7 to 9 kg per month.

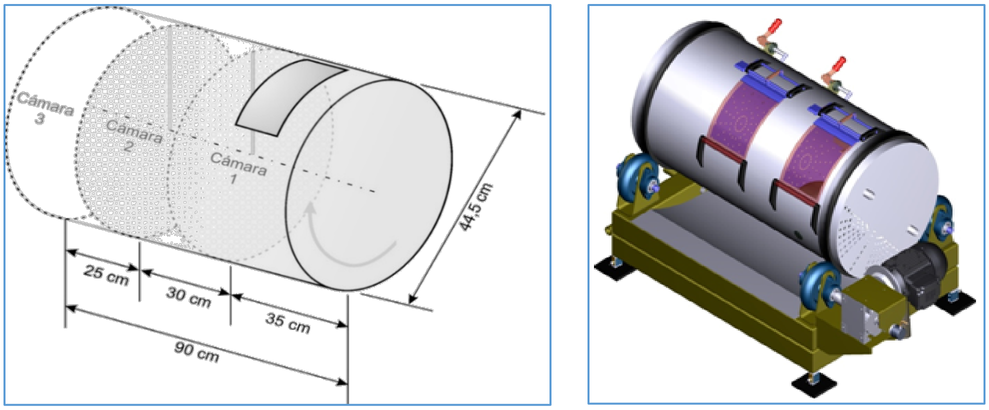


Figure 1. a) composter divided into 3 chambers, b) 3D model of the composter

The process of water purification held in the sewage plants at Buenos Aires City are divided into two parallel parts, one where the treatment of the effluents is made, and another where the produced sludge is treated.
In the effluents treatment phase, the deposited compost that comes from the composter will remain inert, since it involves physical separation.
In the sludge treatment phase, there is an anaerobic treatment to obtain biogas. Another form of sludge treatment is aerobic, as in composting, a highly sustainable option regarding environmental impact.
In the aerobic treatments, co-composting has a positive impact on the final compost, bringing advantages such as a lower generation of leachates, a shorter treatment time and better compost quality.

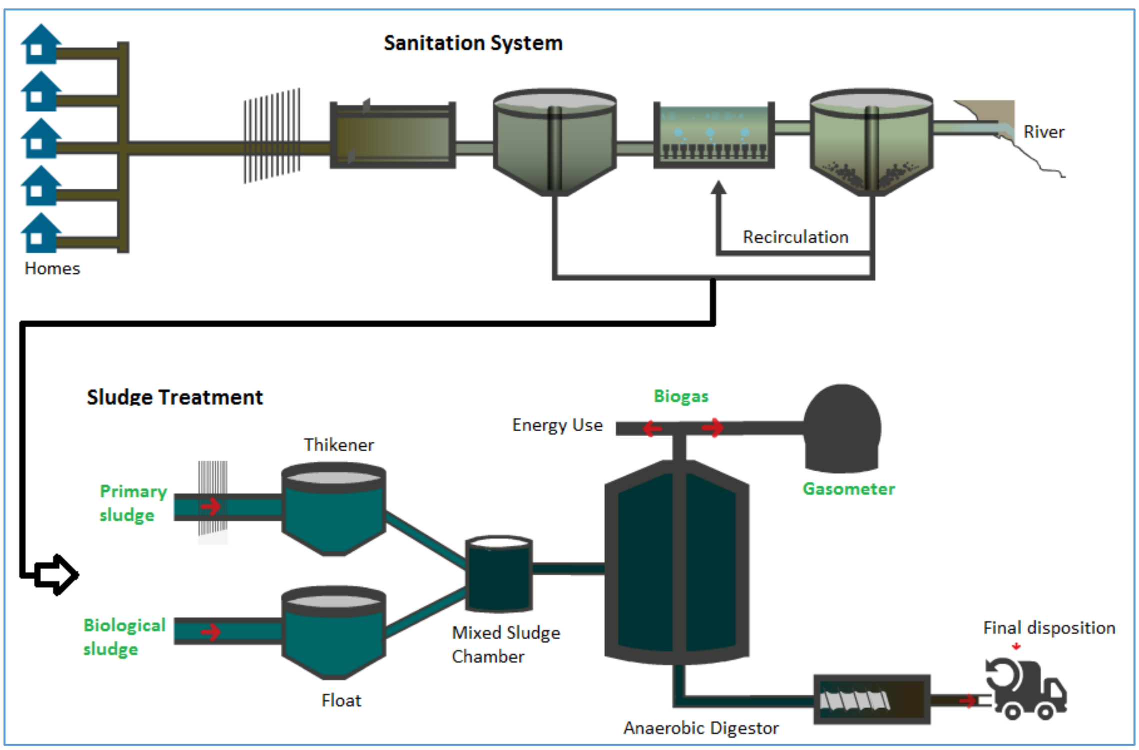


Figure 2. Sanitation System phases at Buenos Aires City, Argentina.

2.2 Economic and Financial Analysis

This analysis intents to prove that the project can be self-financing, and it will be given differently for people living in apartments than the ones at houses. In the first year of the implementation people who move to new buildings will be required to pay for the composter, which will already be installed in the new apartment as an additional sanitary facility. From the second year on, it will also be demanded to be placed in houses, to whom government is going to give subsidies to finance the equipment needed.

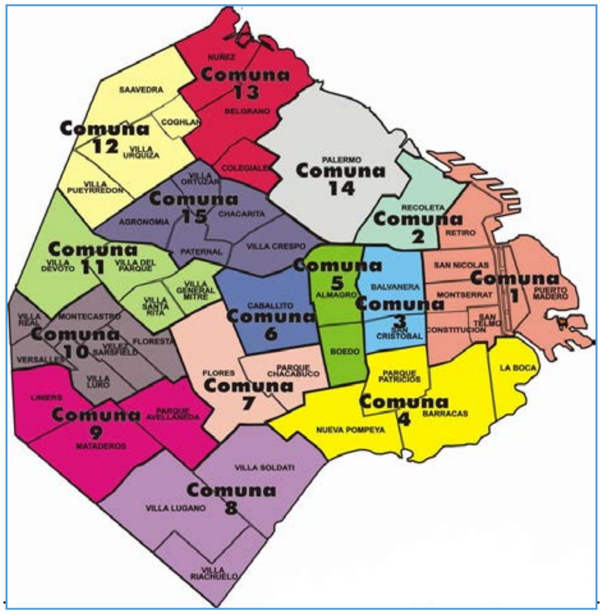


Figure 3. Buenos Aires City map, with neighborhood and commune divisions.

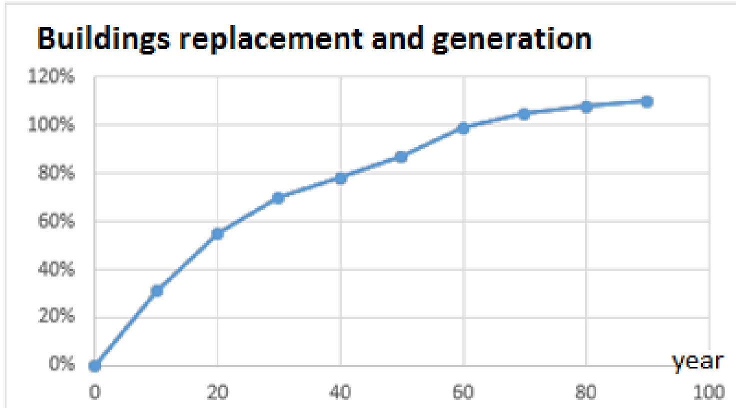
To calculate the maximum savings budget, the volume values of organic USW generation are obtained and hence the cost involved to organic USW per person. With these values, the average inhabitants in each type of housing and the total number of houses, the total possible savings are obtained. This amount of approximately USD 38,000,000 represents the 1% of the total City budget, what undoubtedly signifies a noteworthy impact for local economy.

	Average inhabitants	Living places	Potencial savings (USD)
	2,35	728.833	26.585.116
	3,39	202.564	11.481.489
		TOTAL	**38.066.605**

Table 1. Annual saving opportunities in Buenos Aires regarding waste budget, according to each type of living place.

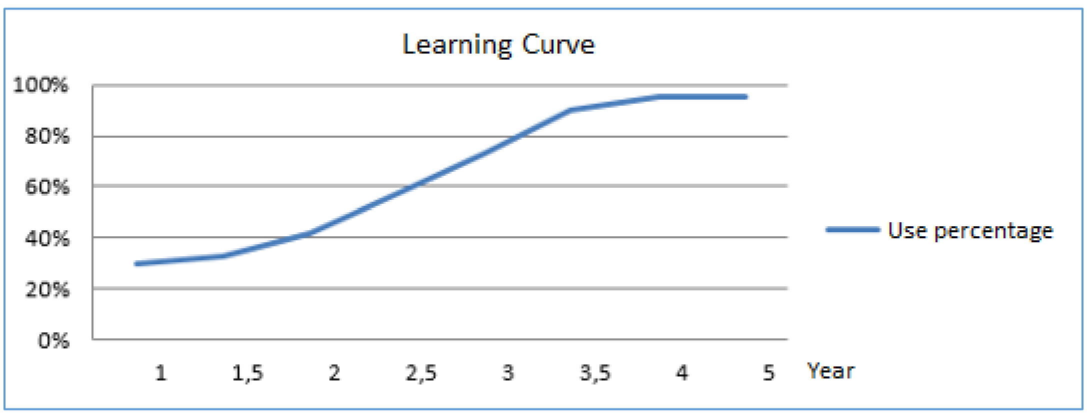
As said before, there is an interest in starting to implement the project in the new plant of buildings. That is why the rhythm of building renovation needs to be understood. The data presented in the following graphic predicts that in 90 years not only all buildings in the city will be replaced, but also there will be 10% more buildings than today, as houses will be replaced by buildings, and the average inhabitants per department will be a smaller amount in the future.
There is also a law in Buenos Aires City (N° 2548) that protects the buildings prior to 1941, as a historical heritage, so in addition to this rate, 4070 departments cannot be renewed.

Year	% Replace
0	0%
10	31%
20	55%
30	70%
40	78%
50	87%
60	99%
70	105%
80	108%
90	110%



Graphic 1. Building replacement rhythm in Buenos Aires City by year.

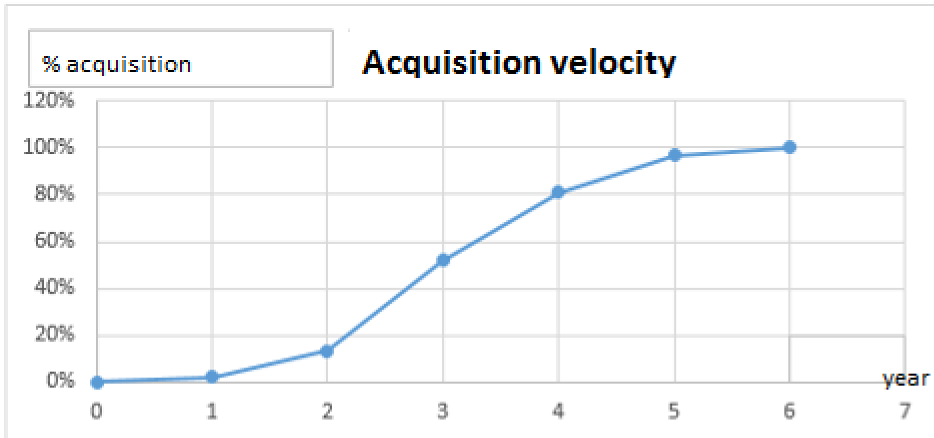
In order to model a learning curve, the implementation of the composter was compared to the introduction to the market in some cities of the United States of the non-recyclable trash crusher, which discards the resultant by sewage.
A "punishment" index of 0.95 is applied to the learning values of the crusher since it is considered that the composter is subtly more difficult to handle because it has to generate an incremental separation of residues since, unlike the crusher that supports all non-recyclable waste, the composter only accepts organic waste from this group.
From this curve it is evident that only after year 4 from the acquisition of the composter on the part of the individual we can perceive 95% of the estimated savings without reaching 100%, a value that would be unlikely to happen.



Graphic 2. Learning curve, representing how people adapts to the composter usage

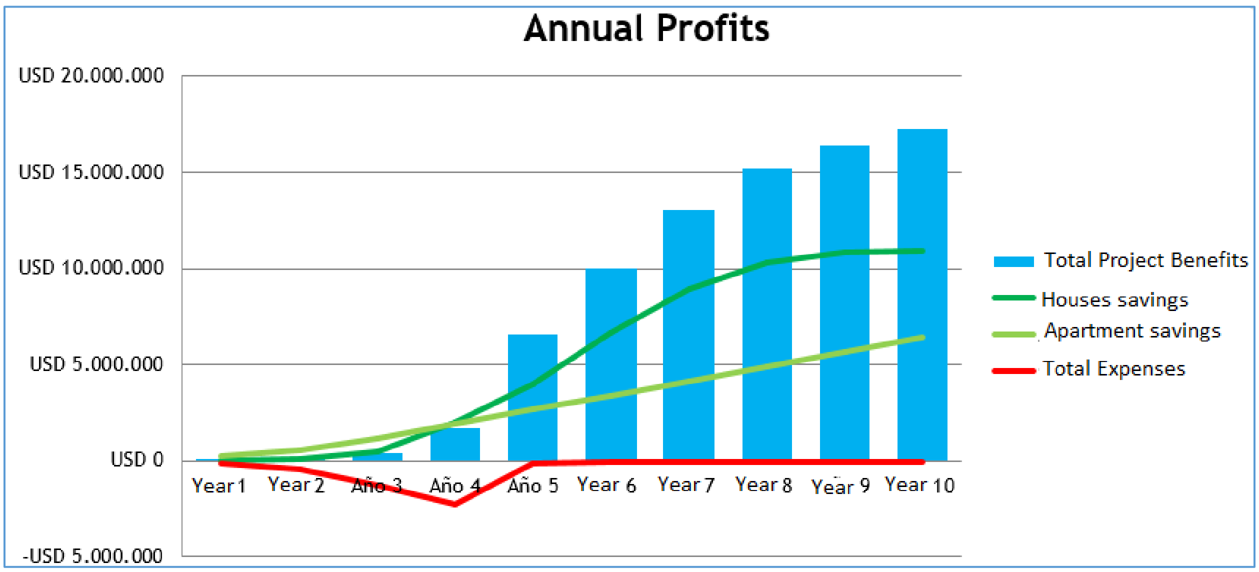
The data to generate the curve of rhythm of acquisition of the composter by the people were obtained from a survey that was made to inhabitants of houses of all the city, taking cases from each neighborhood to obtain a representative sample. More than 400 effective responses were obtained.
It is observed that the shape of the curve is an "S", which is typical result for innovative and technological products.

year	% acquisition
0	0%
1	2%
2	13%
3	52%
4	81%
5	97%
6	100%



Graphic 3. curve of acquisition velocity by people for the composter

Next graphic shows how at the beginning of year 4, the curves of savings for houses and departments intersect. This is because the adoption curve in the houses has a greater slope to the curve of building refurbishment of buildings, even though they represent a larger volume, which is why after some years after those represented in this chart the curves will be intertwined again.



Graphic 4. Expenses and benefits by type of living place year by year.

3. Results and Discussion

As every social project this one also brings social benefits, which are measurable or non-measurable depending on the type. For this study, these externalities were not taken into account to decide the economic benefit of the project, but as a summary the following are stated:

• Reduction of the presence of epidemiological vectors in the public highway (flies, rodents, etc.)

• Improvement in the operation of the sanitary landfill in which waste is disposed, as a lower volume of leachate is generated because of the absence of the organic fraction.

• Minimization of the appearance of odors associated with the anaerobic decomposition of organics during the waste generation at homes, its transport to the transfer station and its final disposal.

• Reduction of the carbon footprint generated by the incorrect waste treatment

• Increase in wastewater treatment efficiency, as well as in the remaining sludge
• Increase in recycling rate due to non-contamination of the rest of the waste fractions
• Reduction of noise and visual pollution in the streets
It is worth noting that during the financial analysis, the most conservative values of the ones available in each case were taken to generate the most conservative of the scenarios and thus expect the reality to exceed or equal these values.
If we take into account that the economic benefits are already obtained in the early years, a policy of total subsidies could be implemented for users living in homes that cannot access it in any way.
Expenditures on total or partial subsidies will cease in a few years, but advertising and training expenses will continue to be incurred by new generations, people who are incorporated in old buildings, among other cases.
In addition, over the years an increase in the number of departments is expected because people will progressively stop living in homes and move to buildings, as was previously said. Additionally, the general habitability index is expected to fall to 2.35 in departments.
Regarding the economic impact for the buyer of the composter, although this does not influence the government, it is observed that for the inhabitant of department does not generate a great change in its economy because it is framed as a sanitary facility more than very low cost, and in the household, it is even shown that the economic benefit can be perceived by the user if the compost is directly used or marketed in some way.

4. Conclusions

The main objective of the USW management is to recover the highest percentage of waste obtaining value, either through recycling, composting or incinerating to generate energy. It is established as necessary the separation at origin, and as a regulatory policy are used methods of benefits and punishments for which the regulation fails.
Buenos Aires propitiates the separation at source (recyclable and non-recyclable) but the percentage of waste disposal is relatively high, and little or no value is obtained. The local context of waste generation reflects the need to manage solid waste in an intelligent way, with careful selection and sustainable development in the use of technologies, establishing a relationship between society and the authorities that manage waste. This forces the participants, both government and society, to commit to the ecosystem.
Throughout this study it was wanted to revise the final deposition options resulting from the treatment of domestic composting in terms of its technical and economic analysis.
As for the technical verification, the option of disposal by sewer, it was possible to verify that there is an affinity relationship between sewage sludge and organic waste compost which not only generates the acceleration of the digestion process of these sludge, but also Improves its final quality by having it added nutrients and purifying biota in this way. The important thing to emphasize also is that the stabilized compost that would dump in the cloaca will not add gases to those already generated by the anaerobiosis, since the organic fraction of the RSU already enters treated. The same happens with the measurement of organic fraction, which would not increase when the organic matter is already digested.
As far as the possibility of obtaining the compost as a fertilizer from the technical point of view, it is verified that, either for its personal use in amendment of gardens or for commercialization with the agricultural sector, this type of use generates a benefit for whom it produce.
As for the economic aspect, it was wanted to verify that in this project would generate a saving for the government of the City to reduce the organic fraction of the garbage, and that there would be no loss of capital in any exercise from the implementation of the project. The implementation of the composter in sync with Buenos Aires's building renovation gives the government a saving in all fiscal periods, allowing part of these funds to be distributed to training, publicity and subsidies to house dwellers, favoring the latter decision to increase the benefits every year. Although a horizon of confidence was determined for the 3-year project values, after this time, an ex-post analysis could be done to evaluate the existing conditions. In light of the results obtained on both the technical, economic and financial aspects, the domestic installation of the composter is convenient for the reduction of the USW in Buenos Aires, generating savings in the City budget. It is hoped that this project will serve as a guide and pilot test for the development of the same type of plan in other cities of the country, and tomorrow we will be able to insert Argentina into the global commitment to the future of our and the next generations.

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Biography

Victoria Willson is currently developing a PhD at the University of Buenos Aires. Ms. Willson holds a Master of Science and Engineering (MSE) in Industrial Engineering from the University of Buenos Aires.

Facundo M. Calcagno is currently a fulltime consultant at Paradigma S.A and Assistant of Chemistry at the Engineer Faculty of the University of Buenos Aires. Mr. Calcagno holds a Master of Science and Engineering (MSE) in Industrial Engineering from the University of Buenos Aires.

Susana P. Boeykens is the head of the Chemistry Laboratory of Heterogeneous Systems (LaQuíSiHe), full Professor of Analytical Chemistry at the Engineering Faculty of the University of Buenos Aires. She earned Master in Chemical Sciences from the Natural and Exact Sciences Faculty of the University of Buenos Aires and PhD in Chemical Engineering from the Engineering Faculty of the University of Buenos Aires.

Néstor Caracciolo is researcher at the Chemistry Laboratory of Heterogeneous Systems (LaQuíSiHe), full Professor of Chemistry at the Engineering Faculty of the University of Buenos Aires. He earned Master in Chemical Engineering and PhD in Chemical Engineering from the Engineering Faculty of the University of Buenos Aires.