Chapter 12
A Circular Model of Residential Composting in Mexico City

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Abstract The urban solid waste (USW) in Mexico City is managed at the municipal level. This situation means several challenges: the 3-year municipal administration period clearly affects the continuity of their USW management plans and programmes, adding to the space shortage problem to properly landfill them. Even further, the technologically insufficient operation of landfills represented 16% of greenhouse gas emissions in 2016. Organic waste represented between 45% and 55% of the total USW. Therefore, grassroots initiatives were the focus of this research because some of them proved to reduce USW at the household level, because activities to turn the organic waste into compost by community members are relevant. This fits into the purposes of the circular economy and zero waste landfill. Local composting has an important potential to improve USW management: the goal of this paper was to identify the conditions necessary for those projects to be successful. Hence, our research question is as follows: Which are the conditions needed to facilitate the community-based compost production? To answer it, international cases were analysed to learn from the existing best practices. Two countries were used as reference: the United Kingdom and the Netherlands. A proper literature review was carried out to build the analytical framework to assess one specific case study in Mexico City: the composting plant Club de Golf Bellavista (CGB). Surveys and interviews were carried out in order to compile empirical data and information for further analysis. Among the most relevant findings, "social participation" came across as a relevant factor in this type of grassroots initiatives, particularly at the source generation of the USW. This was consistently mentioned through

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M.-L. Franco-García et al. (eds.), *Towards Zero Waste*, Greening of Industry Networks Studies 6, https://doi.org/10.1007/978-3-319-92931-6_12

surveys responded by CGB stakeholders. Neighbours also had the opportunity to suggest different mechanisms that could convince other neighbours to engage in the separation phase of USW.

Keywords Compost · Residential areas · Organic waste · Sustainable scheme for local communities

12.1 Introduction

Through the study and benchmarking of two successful USW management programmes in the Netherlands and the United Kingdom and the study case in Mexico City, it was found that by sorting residues, they may be reduced and recycled. This contributes to create a circular economy in the community as well as to achieve the goal of zero waste to landfill.

The waste management in Mexico is a very relevant problem due to the lack of effective mechanisms to reduce, reuse or recycle the discharged materials post consumption and the poor culture to recover materials. This is accompanied by scarce policy instruments that either incentive or force citizens to manage their wastes in a more environmental friendly fashion.

Through the analysis of documents and interviews carried out in Mexico, the United Kingdom and the Netherlands, it is possible to propose a scheme to manage and handle household waste, specifically the organic waste, which represents between 45% and 55% of the USW in Mexico (Álvarez 2002). Organic waste can successfully be recycled by producing compost, which can be easily done by members of local communities.

The compost plant used in this study case, operating since 2008, is located in Bellavista, in the municipality of Atizapán de Zaragoza in Mexico State. Compost produced from the households' organic wastes works as a soil improver, substituting the use of chemical fertilisers in the green areas inside the residential area, which has had reduced the costs for maintenance of green areas. To replicate its process in other residential areas, the scheme needs improvement.

Some similar cases to Bellavista were found in countries like China and Bangladesh, but it was the United Kingdom which had one of the most interesting schemes. There, the community compost plants are a common way for organic waste recycling, and the existence of a community compost network is also analysed as a next step for waste management in Mexico. In fact, social participation was identified as a vital aspect for compost plant operation. If local people do not separate their waste, compost production would be impossible.

The investigation focuses on the collection of organic waste from houses in order to develop a low-cost recycling process by producing compost within a community and create best practices based on the experiences analysed.

12.2 The Problem of Waste Management in Mexico City

Waste management is the responsibility of local authorities or municipalities. In spite of elaborated regulatory environmental frameworks, these are insufficiently enforced due to limited capacities and poorly observed social participation that is reflected in the lack of waste separation. This latter is one of the most important barriers towards an efficient waste management.

The municipal waste is divided into non-perishable or non-biodegradable residues (glass, laminates, plastics, etc.) and organic waste. Waste is regarded as organic if it is biodegradable and can be absorbed, almost naturally, back into the environment. In the case of Mexico, non-biodegradable waste generates "scavenging": a process of selection and classification that allows to take advantage of 5–10% of waste (Herrera 2004) in various industrial processes.

Organic wastes are being underutilised and scattered over large areas of garbage disposal (open dumps), which are permanent sources of pollution. Likewise, there is no recycling culture in Mexico, and there is a shortage of collection centres in order to reuse and recycle waste, either organic or inorganic (Castillo 2002).

It is also known that the collection of waste is not efficient, because of the scavengers' interests. Therefore, there is an irregular collection of waste, and collectors fight over waste zones in the city, preferring areas which pay more to get their waste collected (Bernache 2006).

Needless to say, Mexico City's landfills have exceeded their capacity. Although efforts to recycle have been made to produce compost and generate biogas to create electricity for the municipality of Atizapán de Zaragoza (Medellin 2015), this is not enough when considering the lack of law enforcement and of mechanisms that could encourage citizens to separate their waste.

When residues are only disposed into landfills, the pollution of water reservations also represents a problem. Another consequence is the shortage of space for waste disposal in landfills. On the other hand, this can also be considered as an opportunity for the implementation of community composting programmes in order to reduce organic waste dumped into landfills.

Dumping wastes in landfills is both a public health and environmental risk. Since it is a cycle of environmental pollution, the leachate drains from the slopes or filtrates into the subsoil, and this often has the characteristics of hazardous waste (Restrepo and Phillips 1991). Waste also attracts vermin such as rats, flies, other insects and worms that live and reproduce in large quantities. They foster diseases and, as the wind distributes large amounts of waste in vast areas, damage the natural environment. These reduce the quality of life thus having negative effects in aspects like hygiene, health and public welfare (Dennis et al. 2006). Society puts pressure on the natural system, and finding options to restore an appropriate interaction between the actions of the social and natural system becomes necessary (Vicente and Reis 2008).

Additionally, composting in local conditions impacts positively on the operation of the municipality and is valued internationally because of the greenhouse gas

reduction. This has been supported by the Mexico City government through its Environmental Ministry (SEDEMA, for its Spanish acronym) since 2006. Greenhouse gas emissions in residential areas in Mexico City constituted 9.8% of the total emissions. The biggest landfill in Mexico City is *Bordo Poniente*, which receives approximately from 4,380,000 to 5,110,000 tons of waste and emits 2 million tons of carbon dioxide into the atmosphere per year (La República 2008). In Mexico City, USW represents 16% of greenhouse emissions (Mejia 2016).

In this research, the landfill *Puerto de Chivos* was studied due to its proximity to the area of the case study: the Compost Plant in the Residential Area in *Bellavista*. In that landfill, 500 tons of wastes are disposed, although it has been restricted since 2007 because of its limited space (Medellin 2015).

The proposed model for waste management is the implementation of compost plants in residential areas, but in order to do this, it is necessary to analyse the drivers and barriers of the implementation of a community compost plant. These include legal, economic, operative, environmental and social variables. Through the analysis of different case studies from Mexico (MEX), the Netherlands (NL) and the United Kingdom (UK), we suggest best practices and ways to improve the current residential scale model for the *Club de Golf Bellavista* compost plant.

12.3 International Benchmarking Experiences

The two international studied cases (United Kingdom and The Netherlands) are here further described to identify some of the best practices of social participation in waste separation and compost production.

12.3.1 British Case

The United Kingdom is a good example when it comes to observing the best mechanisms to manage waste. Even though they have successful industrial processes for managing waste, there are also local communities' initiatives that cannot be overlooked. These latter are what the research focuses on.

In the United Kingdom, community compost production has developed quickly, and the successful cases are many. Their main objective was to reduce waste from landfills or incineration, thereby preserving internationally important peat land natural habitats and improving the topsoil structure.

Five compost plant's managers answered an exploratory questionnaire with the objective of knowing the incentives and barriers for the implementation of this scheme. These compost plants were the Scottish Composting Centre, Brighton Community Compost Centre, Lower Slaughter Community Composting, Cwm Harry Land Trust and Denton Parish Council.

One of the main motivations to create and implement community compost plants is the international pressure, which leads to the implementation of legal incentives. Another incentive is the money savings that come from the produced compost, because it can be used as fertiliser for the green areas instead of buying chemical fertilisers.

The independent variables contemplated for this study are policy incentives, project management (technology used, financial situation and operation of the plant), manager's perception (which can be translated into the creation of networks) and society's environmental conscience (which can be translated into participation). This helped to know more about the operation of the project and its organisation, the technology used, the financial situation and stakeholders, the environmental impact, management and success factors. The management is bottom-top, because it started from a social initiative and has been growing through the creation and strengthening of community compost networks.

The level of success regarding the implementation of compost plants in the United Kingdom is influenced by the variables described in Fig. 12.1, which were mentioned by the compost plant managers when they were interviewed.

Success includes aspects such as adequate infrastructure, quantity and quality of compost, investment and feasibility of the programme. These aspects were relevant at the first operational stage of the implementation of composting plants, and they are analysed as possible barriers.

When the waste disposed into the landfills is reduced, it has a positive effect in the environment because less waste is transported to final disposal locations and compost is produced near the end user. In the long term, waste could work as a bio-input to generate electricity, and the residues could be used to produce compost. The economic feasibility of the project does not represent an obstacle, because some of the compost plants, like the Denton Community Compost, have the local government support.

One of the most common barriers perceived by the community compost plant managers is that compost production takes a long time (about 80 days), and, in order

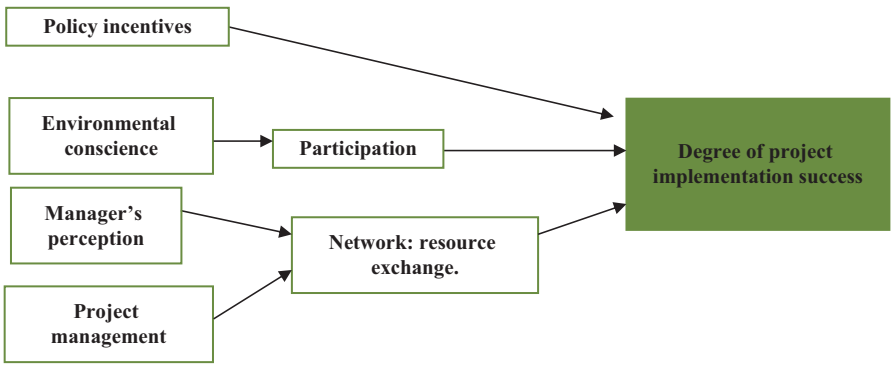

Fig. 12.1 Degree of implementation success of community compost in the United Kingdom. (Own contribution)

to sell the compost, it has to be certified by the "British Standards Institution" (2005) "Publicly Available Specification for Composted Products" (PAS 100), certification by the Composting Association and the "EU Eco-label for Soil Improvers and Growing Media" certification by the Department for Food and Rural Affairs. Among other certifications, there are the "Organic Standards for Landscape and Amenity Horticulture" certification by Henry Doubleday Research Association (HDRA) and the "Soil Association Standards for Organic Food and Farming" certification by the Soil Association (Slater 2004).

These certifications are not mandatory, but in Scotland, for example, in order to be able to claim that waste has been fully recovered, the process/product must meet a nationally recognised standard or specification. If a product does not meet such a standard or specification, the local authority is not able to count this waste towards their statutory targets.

Community composts are allowed in the Environmental Permitting Guidance, Waste Framework Directive which states that households do not require permits for carrying out waste operations involving only household waste or managing of waste within their own property. Disposal of waste by householders is not allowed when it is likely that it causes harm to the environment or human health (Environmental Agency 2008).

The community compost plants analysed in the United Kingdom process organic waste from households, particularly from small communities with maximum 50 households. Waste is processed manually and, in average, it takes 2 months to obtain fertiliser.

If fertiliser cannot be sold, that endangers the feasibility of the programme. Therefore, communities need an environmental permit to start the compost plant and hire people with technical expertise in the production of compost, because if it is not handled in a professional way, it could be potentially dangerous to the environmental and human health.

The United Kingdom scheme is considered a positive practice in this research because it is a bottom-up policy, which could be more likely to be implemented in the Mexican case. The lack of implementation of the top-bottom waste management policy because of stakeholders' interests (scavengers) could create the opportunity for the implementation of private programmes where waste is recycled through community compost, creating electricity or heat.

12.3.2 Composting Network in the United Kingdom

There are several associations and organisations that encourage the creation of community composts through a bottom-up policy which involves direct participation of citizens in the recycling of their organic waste. There is even a community compost network which provides advice and training to its members (Organic recycling 2010).

An example of this is the Association for Organics recycling, (Organic recycling 2010) formerly Composting Association, created in 1995, which promotes the sus-

tainable management of biodegradable resources. The Association encourages a regulatory and economic framework suitable for the long-term benefit and sustainability of the composting industry as a whole. It also centralises information and researches and distributes them.

Lately, the Composting Association has over 700 members from all sectors of the UK waste management industry, including compost producers, regulators, local authorities, consultants, trade suppliers, compost users, academics, individuals and students.

Its purposes are to promote the environmental and economic benefits of effective composting and compost use, promote a quality standard for composts (which includes requirements covering compost production and monitoring), sampling and test methods, compost quality and declaration/application information. The aims of standards (BSI PAS 100:2005) are to assist producers in maintaining consistent and reliable products and to encourage greater consumer confidence in composts. The Composting Association manages the certification scheme (Association for Organic Recycling 2010).

Another example is the Community Compost Network, which has over 230 members who receive a quarterly newsletter and have access to The Growing Heap website, e-mail news list and directory of members, annual conference and training events.

This organisation shares some of the objectives with the Composting Association, such as the development of biological treatment as a sustainable waste management technique, and develops and runs workshops, seminars and training events to improve the skills and knowledge of people working within the composting industry, regulatory agencies, local authorities, professionals in related industries and the general public. It also works with consultancy services (Community Compost Network 2010). In order to be part of any of these organisations, there is an annual fee depending on the characteristics of the applicant.

This particular scheme works because of the lack of industrial production of compost from organic waste. This could be used as a good example for the Mexican case.

12.3.3 Dutch Case

Waste management in the Netherlands has proven to be within the highest European standards, and for such reason, it is considered one of the role models at this regard. This started since 1960, when environmental pollution represented an issue to this country. When the government wanted to act on it, legal instruments did not exist. The government opted for a sector legislation being enacted for each type of pollution. This was not effective because the legislation was too detailed and coordination was inadequate.

In 1990, it was decided that this Act should be transformed into a single integrated piece of environmental legislation. This resulted in the Environmental

Management Act, which came into force in March 1993. This Act stipulates rules regulating the discarding and collection of waste and on its processing, reprocessing, destruction and final disposal.

One of the biggest contributions of this Act is the establishment of rigorous standards for landfill sites and incinerators. Also, the landfill tax tends to make these ways of disposal expensive, thereby encouraging different ones, such as compost plants. Furthermore, the landfill of many types of waste is prohibited (VROM 2010).

Legislation becomes even stricter as years go by, due to the compromises acquired through international protocols. This is why the Third National Environmental Policy Plan set an indirect target for prevention: the growth of waste generation over the period 2000–2010 should be 20% less than the growth of the economy (VROM 2010). The Environmental Management Act regulates the management of hazardous residues, domestic waste, emissions to the air, landfill management and their possible prohibitions, batteries disposal, the car tire decree and the waste oil decree.

There is also a chapter which specifically addresses waste and stipulates the hierarchy of its management: prevention, reduction, reuse, recycle, incineration and finally landfill. Ever since January 1, 1994, the Act mandates that local authorities collect household waste, separating it into organic and inorganic. The organic waste includes garden and kitchen waste, which is processed to produce compost and then used as soil improvers. The provincial environmental management requires local authorities to organise the collection of paper, cardboard, glass, textiles and chemicals away from their source of generation.

The citizens' organic waste is collected once a week, the next week the inorganic waste is collected and so on. Another successful aspect of the Dutch legislation is the green tax, implemented in 1994, for using the landfill. The objectives of this tax are to provide a revenue source to the local government and to have a positive impact in the environment. The fact is that the costs of landfills are lower than using the incinerator, which is why the government decided to increase the price to deposit waste in the landfill. Since the cost to incinerate is lower, people are incentivised to separate their garbage to be used for incineration and compost production.

In many cities, this tax is calculated according to the weight of the garbage or the number of times a garbage can is presented for emptying. The revenue raised by this tax was estimated at 117 million Euros in 2005 (VROM 2010).

Taking this into account, a case from the region of Twente, which is located in the province of Overijssel, eastern part of the Netherlands, was studied. This region has three large cities: Hengelo, Enschede and Almelo, which have 77,500, 150,000 and 65,200 inhabitants each one (Business and Science Park 2010). The focus of the research was mainly in the city of Hengelo, where an exploratory questionnaire was applied in the format of an interview to the person in charge of the composting process in Twence, which is a semi-governmental waste treatment company. The interview was divided in six categories: operation of the organisation, technological

innovation and product characteristics, financial situation, stakeholders, environmental impact of the project and management (Medellin 2015).

The region of Twente has a company which is responsible for the waste management called Twence. Since 1986 it has published a sustainable vision, when a landfill and a station for the disposal of hazardous household waste were opened. At that same site, a composting plant began operating in 1994. It was in 1997 when they began selling their product.

At Twence, the entire process of composting organic waste from kitchens and gardens takes place in sealed spaces, using the so-called closed method, which is an aerobic method. The compost is an excellent soil enhancer for agriculture and horticulture, and it is certified by the Authority of Food Safety and Consumers (VWA-erkenning, for its Dutch acronym), which verifies that the compost plant operates under legal requirements of the norm 1774/2002, which allows the mixing of animal byproducts with organic waste that has been used for compost, whose source is gardens and home kitchens, used under hygienic conditions.

The certificate, BRL [National Beoordelingsrichtlijn] GFT Compost, is specifically for the compost produced from organic waste that comes from kitchens and gardens. The certificate BGK [Bundesgütegemeinschaft Kompost e.V.] allows the sale of compost produced in Twence to Germany.

There are two end products: green compost (consisting of elements of 0–10 mm in size) and coarser wood components (larger than 10 mm in size). The latter material can be used as a secondary fuel, intended to be used as such in the biomass power plant. By means of this process, Twence is able to treat 30,000 tons of green waste each year (VROM 2010), and over 90% of the waste received at Twence is transformed into raw materials, building materials and energy (Twence 2010).

The process is feasible because Twence receives money for processing waste. In the case of the incineration of waste, the electricity and the heat produced are sold to inhabitants of the region or other countries. In the case of compost, it is given away for free to nearby farms. This scheme is environmentally friendly, and Twence takes into account the neighbours and the inhabitants by avoiding odours in the waste treatment. That also works as a strategy to motivate people to separate their waste (Twence 2010).

As far as social interaction, there are also reported cases of citizens' complaints about unpleasant odours and noise, litter, excessive traffic and nuisance from birds; these are indicators that reflect aspects that could upset inhabitants, and the plant takes them into account each year in order to improve its performance.

In the framework of the plan set out in 2006 to further reduce the odour impact of the plants, they have worked on better timing of the turning of the composting materials and overflow with regard to the weather conditions, such as the direction of the wind. At the post-composting phase, a door has been replaced with a so-called quick-lock door, whereby less emission of the process air is achieved. Finally, the compost produced from organic waste separation is used by farmers as soil improvers.

By analysing the situation of waste management as a project in a local scale in the Twente region, it is easier to understand what are the drivers and barriers for the

implementation of this policy, which could represent a successful model. The success factors are understood when variables such as the project's environmental impact, stakeholders' participation, financial aspects, legal aspects, technology used and the operation of the compost plant are taken into account.

These variables were considered in a questionnaire, which was applied in an interview with the Twence compost plant manager (Tcpm). He implied that the governments' decision to change the public policy on waste management began with the lack of space to landfill the waste. When this issue became more relevant, the Netherlands' government approved a strict regulation on waste management, where every household has to separate their waste into organic and inorganic (Ministery of Housing, Spatial planning and the Environment 2001) in order to process it more efficiently into electrical energy, heat and/or compost. That is why this scheme considers managing the organic waste in an industrial level, instead of a small-scale community compost plant.

In the region of Twente, there is no competition in the processing of waste and production of compost. In the words of the Tcpm:

> We live in the east of the Netherlands and here is no problem as people separate the trash. We have the potential to grow because our raw material is constant and now we process waste from Germany and other parts of Netherlands. Since 2001 we opened the plant to treat waste from Rotterdam and Amsterdam and since 2008 from Germany too.

The first step in the process to produce compost starts when the organic wastes from households are contained in green bins and are brought to the compost plant. When it arrives, it is sorted out again to take out the plastics, glass and metals (Tcpm, personal communication, June 15, 2010).

Afterwards, thick matter is crushed to reduce its size until it is less than 140 mm, and then it is taken to one of the tunnels where compost is mixed and processed aerobically with the help of computers, which control the temperature, moisture and oxygen to ensure that bacteria, fungi and microorganisms do their job. The resulting ash from incineration is also included. During this stage of pre-compost, temperature must remain at 60 °C, to remove weeds. During the process, biofilters containing bacteria and fungi purify it. After 12 days, most of the material is composted and taken to an area for the post-compost stage, where it stays for a week. The final result is compost which can be used as potting soil in agriculture.

In 2009, over 92,000 tons of waste was recovered for compost elaboration, which is almost 7% more than in 2008. This is due to increased efficiency of the composting plant: the trituration of thick matter improves the process. After composting through tunnels, waste is filtered through a strainer, where wood and other rubbish from the compost are collected to be used as a biofuel for producing energy, steam heat or electricity. Of the 147,894 tons of biomass burned in 2009 at the incinerator BEC, 20% of it came from waste in the composting plant (Twence Annual Report 2009).

The manager of the composting process in Twence (mcpT), mentioned that each year, they try to be greener with the waste management by producing electricity, biomass and heat from the incineration of waste. He also said that one of the barriers

encountered is that they are paid by ton of waste, which has decreased from 50 Euros per ton to 25 Euros per ton, and now they have to look for alternatives to be profitable. Another barrier is the smell that emerges from Twence, which generates complains from the neighbours. The compost plant is forced to prevent this by cleaning the air before it goes back to the atmosphere, and it costs a lot of money. The mcpT also said that they earn the money from the organic waste that they receive, but they must pay farmers to get the compost produced. Another barrier mentioned is that the plant depends on what the government decides on waste legislation.

An area of opportunity is that soil in the Netherlands is getting (mcpT, personal communication, June 23, 2010), so it is expected that people will use more compost from the Twence plant as a soil improver. Finally, the mcpT believes that the tours in the Twence plant are of vital importance because if people know about this type of projects, then they are motivated to cooperate in separating their waste and become potential customers of the products that come out of their waste, enabling a circular economy model for sustainability.

This research addresses the Dutch composting process, which is performed in an industrial scale, but considers the legal and economic instruments applied to stimulate citizens and in particular householders to sort out their wastes. The Dutch case's approach for the implementation of this waste management policy is top-bottom, which can still be used as a reference for future recommendations in the Mexican situation.

12.3.4 Mexican Case

In this section, the Mexican case is studied considering the municipal landfill scheme as a way to manage residues, as well as the particular case of the community compost model used in a residential area in the same municipality (Atizapán de Zaragoza).

12.3.4.1 Compost Plant in *Puerto de Chivos, Atizapán de Zaragoza*

The municipality of Atizapán de Zaragoza participates in a programme of municipal compost which started in July, 1999. Its objective is to reduce the quantity of organic waste that is disposed into the landfill *Puerto de Chivos*, in order to decrease the polluting effects and extend the life of the landfill (Villegas and Franco 2010). According to statistics, if every organic residue was composted, the waste disposed would be reduced by 49%.

The programme consists in the participation of 43 residential areas which separate their waste, but 110 residential areas do not participate due to lack of knowledge and dissemination of the programme in the municipality, which is a barrier for the continuity.

The perception of the Mexican compost manager (Mcm) of the citizens' behaviour towards waste separation is that they believe that even if they separate their waste, it would be mixed again when it arrives to the landfill.

Although they receive visits from schools and international and national organisations that are interested in the compost programme, it is vital to have more dissemination of the benefits. Another obstacle is that this programme's continuity depends on political cycles, which means that every 3 years, when elections take place, the personnel changes. This affects the development of the programme and makes it difficult to improve it when there is a great deal of staff turnover.

In terms of the compost production process, the bio-inputs used are the organic residues from these households: leaves, grass and splinters from parks and green areas in the municipality and manure from cows and horses from ranches nearby and some unidentified restaurants. The landfill receives 500 tons of waste per day, but can only recover 0.8%, which means that it produces 54 m^3 of compost per month (INE 2010).

When the organic waste arrives to *Puerto de Chivos*, scavengers do a manual separation of the garbage because it arrives in plastic bags, which are removed in order to make piles of the residuals found in them. As for the pruning material and grass clippings, the trituration process is done and then mixed in an open space. The production of the organic fertiliser is an aerobic process done in 1000 m^2 of land. The machinery and tools used for producing compost are two backhoes, shovels, a sieve and two big shredders. The compost is only covered with plastic when it rains, and the rest of the waste that could not be used for compost is disposed into the landfill (Mcm, personal communication, June 2010).

Bio-inputs are mixed and then placed among alternating layers of grass until the temperature reaches 70 °C. The process takes 3 months (besides the time of construction of the pile), and it is watered every 3 days, depending on the season, with treated wastewater going through a pipe. The backhoe flips are made once a week or when machines are available.

The potential hydrogen is not measured. They only have an approximation from the carbon-nitrogen relation, by using "brown" inputs like fallen leaves and manure, which represent the carbon, and the "green" inputs like organic material, and grass, which represent the nitrogen. For the aeration of the compost, they installed tubes. The compost is not sold, just given away to use it in parks or at the request of citizens. The quality is not measured through chemical analysis, even though there is a norm in Mexico City that establishes the standard.

In the economic aspect, *Puerto de Chivos* does not have a long-term plan for the compost plant. In terms of budget, the costs of the plant per year are $201,896 Mexican pesos[1] (INE 2010). The feasibility of the plant is not known because they do not make annual reports of their performance; they have a lack of transparency in their management, and the municipality does not sell the compost, so there is no return of investment.

[1] Equivalent to $16,023 USD (exchange rate: $12.6 pesos per USD in July 2010) according to http://www.banxico.org.mx/portal-mercado-cambiario/

Although there have been some efforts in Mexico to implement composting plants, they have been an economic failure and in most cases have been closed. Among many reasons that have led to discard the use of composting in Mexico is the lack of market for this product, which use is restricted to agriculture as a soil improver (Semple and Fermor 2001).

On an exploratory visit, we had an interview with the manager of the municipal compost plant. We asked him about the production process of the organic fertiliser done in *Puerto de Chivos*, and he answered:

> The process could take from 3 to 5 months, depending on the level of humidity and temperature, and as a result 70 m^2 of compost are produced.

Atizapán de Zaragoza is biologically treating the waste, but it does not have the necessary technology to do it. We asked the compost manager what would they do if more people separated their waste: would they be able to increase their production capacity? He answered the following:

> Yes, we have enough space to produce compost… If more people separate their waste in their houses, it is better for us because although it implies more work, it is worth it.

Since this programme has some deficiencies, a residential area called *Bellavista*, which is one of the residential areas that participates in the programme of waste separation, started a community compost plant. From the research done in the community compost plants in the United Kingdom, the variable of social participation was identified as the most important variable because it can start and drive a community compost plant or become a significant barrier. That is why it is important to know what the drivers and barriers for the Bellavista's community compost plant are.

12.3.4.2 Study Case: Club de Golf Bellavista

Club de Golf Bellavista is a residential area located in *Atizapán de Zaragoza*. It has 80 hectares and 345 houses. The total households' waste had been taken to Atizapan's landfill called *Puerto de Chivos* before the local compost plan started in 2008.

This initiative started with one neighbour, who is an environmentalist, when she proposed the idea of a compost plant inside the residential area. She convinced the neighbours' associations, which then realised that the problem of waste management in Mexico City is not solved by local governments yet. They were motivated to use less pesticides, chemical fertilisers, ammonium sulphate and urea in green areas and also realised they could take advantage of the organic residues instead of sending them to landfill while having economic benefits.

Subsequently, the programme was announced to each neighbour, but only a small percentage of them separated their waste. It is also important to mention that this residential area has a social club with a golf course, a restaurant and a kinder garden. Most of the food residues from the restaurant are used in the elaboration of

compost; gardening waste from households is used as well, but it is not enough because if more people separate their waste, the compost produced could be used not only in green areas and some of the houses' gardens but in the golf course, thus producing an even greater impact (Martinez 2009).

It is important to mention that the green residues from pruning the golf course most of the times are not used for the elaboration of community compost. However, this would have to be done if the official norm NOM 140 SEMARNAT 2005, which establishes the general environmental requirements for golf courses and real estate development that includes golf courses, is approved. This norm established that the grass and other organic compound derived from the maintenance of the project areas are meant to be used for compost, fodder or other purposes to ensure reuse (SEMARNAT 2005). This norm is not mandatory yet.

According to the manager of the compost plant in Bellavista (mcpB), they could represent a sustainable model for waste management in a community scale:

> We have an ecological corridor, which can be visited by the Bellavista neighbors and general public. We produce compost and we also have a nursery area, compost produced by worms and an area of medicinal herbs. This is a scale model of what people can do to recycle organic waste. The next step is to increase the area destined for the compost area in order to sell at a low cost the compost produced here.

The area that they have is an ecological corridor which has medicinal plants, a plant nursery, and also vermicompost. This could also serve as a model for other residential areas with similar characteristics as Bellavista.

The continuity of the community compost plant in Bellavista relies in the fact that there is an institutional figure in charge of the production of the organic fertiliser called *Asociación de Colonos de Bellavista*. But it is somehow informal in its operation due to lack of official records on waste received at the compost plant. The area destined to treat organic waste is approximately 75 m^2, in an open space, and they have to be very careful with the right production of compost in order to prevent the presence of vermin and odours.

The advantage is that the quality of the compost fulfils the standard that Mexican regulation states for good soil improvers. Since the technique to produce the fertiliser is accelerated by the bio-inputs, this could represent a success factor.

Club de Golf Bellavista also considered different alternatives in order to stop using pesticides, but the most feasible was recycling organic waste through aerobic biological treatment, commonly known as compost. Economic, social and environmental aspects were considered when the decision was made. This treatment is not expensive to implement in residential areas, as explained further by the mcpB.

In order to start modelling the composting plant in Bellavista, the scheme had to be divided into levels by using the diagrams of Forrester (Forrester 1991), which also constitute different phases: compost in process, householders who separate their waste, required personnel and maintenance costs.

Therefore, translated into mental models, the behaviour of each level can be described by using the following:

- *Compost in process:* steady increase, reaching a peak due to the limited space for composting and other resources.
- *Householders who must separate their waste:* it is contemplated as a constant increase, where householders start to separate their waste until it reaches its peak, which is 345 households.
- *Required personnel:* it is contemplated that the number of people in charge of the composting process increases when the quantity of inputs is more, but since the space is limited, the maximum level of people engaged in the process is four.
- *Maintenance costs:* even though there are some fixed costs such as workers' wages, and gasoline for the garbage truck, the model reflects that the maintenance costs are reduced (Forrester and Martin 1997).

For instance, the quantity of *organic matter* is a rate fed by the quantities needed to produce compost. This rate is linked to the level called *compost in process*. After that, the level *compost in process is* translated into a rate called *resulting compost*. The *resulting compost* is the result of all those variables. This is the way the model behaves.

It is a complex model because it involves many variables, but it has been simplified. First, the time frame within which the scheme is assessed lasts 24 months, which implies that many variables are remaining constant, like the production area, the machinery and tools used, an approximation of the quantity of waste produced in each household per month and the number of households. The evolution of the process is analysed every month during this time frame.

It is important to know that, in order to work, this particular scheme has to consider variables like an area destined to process compost and people trained in waste management through composting. Management of the compost plant is mainly voluntary through the neighbours' association of *Club de Golf Bellavista*, where the only ones paid are the waste collectors which are trained in order to know where the organic residues have to be taken (mcpB, personal communication, June 2010).

Throughout the year, pruning of house gardens, green areas and the golf course is done. This translates into raw materials for the production of compost, which is then used as fertiliser in the green areas mentioned. Another aspect is the separation of garbage from the neighbours in organic and inorganic. This makes it easier to use organic waste to nourish the compost, so the more it increases, the more fertiliser for landscaping there is.

There are some periods in which more organic waste is produced, such as winter, when Christmas trees are discarded; those periods demand more personnel for the compost production (mcpB, personal communication, June 2010). In the model, it is assumed that a person can handle up until 3000 kg of organic matter. When the personnel reach four people, it is considered that they are enough since the space of the compost plant is relatively small, and in this way, the maintenance costs for the green areas do not increase dramatically.

Organic matter produced in Bellavista is later processed and packed into bags that weight 30 kg each. As a result, in winter more compost is produced and exceeds

the compost demand for the maintenance of green areas in the residential area, which is why it can be sold.

The interaction of different "systems", mainly the economic and social ones, is considered in order to prove that this could become a sustainable model for waste management in residential areas with similar characteristics. The generation of compost could save money because the organic material is used in the maintenance of green areas; it reduces costs when the amount of trash collected decreases and fewer trips are made to the landfill. This implies lower costs in waste collection and disposition of residues into the landfill.

The level of maintenance costs decreases each month until it reaches the lowest point on the 8 month of the first year. The economic benefits of this compost plant include the creation of three more jobs, sales of the compost produced and savings, so it is a feasible model. The typical maintenance costs before the implementation of the composting programme were approximately $55,212.00 MXN pesos[2] per month (mcpB, personal communication, June 2010), but when the compost plant started, the typical costs were discarded and replaced with the organic residues as bio-inputs for compost production.

The model represents the behaviour of the programme if all organic residues were used in the production of organic fertiliser. The assumption is that the number of neighbours in *Bellavista* who separate their waste and used for composting increases. Savings are presented although trained staff has been hired for the operation of the plant.

The total maintenance costs after 2 years of operations are $138,530.42 MXN pesos,[3] which imply savings of $45,000 MXN pesos[4]; therefore, it is a viable proposal to be implemented in other neighbourhoods without additional costs. It is important to mention that without the neighbour's participation, this scheme is not possible.

In the proposal, when the resulting compost exceeds the compost required for the green areas, bags of compost could be sold to external members of the community in $90 MXN pesos[5] each. As a subsequent proposal, the compost could also be used in nurseries. In a period of 24 months, the compost sales could generate an income of $305,211.60 Mexican pesos.[6] In the long run, vegetables and plants derived from the *Bellavista* nurseries could be marketed. Therefore, it is a sustainable project as it provides economic, social and environmental benefits.

It is important to note that social participation in the separation of organic waste could represent a barrier for the success of this project. In order for it to work, it is vital to inform that the only bio-inputs used for the production of compost from kitchen are vegetables, fruits, eggshells, grass, branches and Christmas trees.

[2] Equivalent to $4381.9 USD (exchange rate: $12.6 pesos per USD in July 2010)

[3] Equivalent to $10,994.47 USD (exchange rate: $12.6 pesos per USD in July 2010)

[4] Equivalent to $3571.42 USD (exchange rate: $12.6 pesos per USD in July 2010)

[5] Equivalent to $7.14 USD (exchange rate: $12.6 pesos per USD in July 2010)

[6] Equivalent to $24,223.14 USD (exchange rate: $12.6 pesos per USD in July 2010)

The compost plant manager (mcpB), explained that not every household separates its garbage; approximately 10% of the neighbours have not participated ever since the compost plan was opened in 2008. Because the space to produce compost is small, it does not seem as a priority to promote more waste separation at the time, but the space is expected to increase, and generating more awareness among the Bellavista's neighbours would then be necessary.

Since social participation could constitute an important barrier for the continuation and growth of this community compost plant, this led to suggestions to increase the awareness of the environmental and health benefits of this. One of the main suggestions was to inform the community about the compost plant inside the residential area and to inform the neighbours what kind of organic waste could be used in the production of the compost or organic fertiliser. This is an important aspect because they assume that all organic waste can be used for the production of compost, when in reality some bio-inputs are not used, such as meat and bones.

The following results represent the most relevant variables analysed in the questionnaire on social participation in Bellavista, which influence directly on the neighbours' attitudes and behaviour towards waste separation. The results are the following: 40% of the neighbours who know about the compost plant separate their waste; 33% who know about the compost plant do not separate their waste. The main reason that keeps them from separating waste is that neighbours think it is useless to do it because it usually is mixed once it is picked up. This highlights the lack of a good communication between the compost plant managers and neighbours. Neighbours should know that if they separate their waste, the organic residues could be used in the elaboration of compost used in green areas, and they could also request it for their gardens.

After knowing this situation, it was important to know if the behaviour and attitude towards waste separation is related to gender, age and education level. The majority of the respondents were women between 45 and 65 years (73.3%), of which, only 33.3% separate their waste. When considering the education level of the neighbours, the majority studied until college (56.7%), but when it comes to separating their waste, 64.7% of them do not separate their waste. This does not seem logical, that is why people that do not separate their waste were asked if they had a particular inconvenient that prevents them from separating their waste: 29.4% said that they don't have the habit of doing it or they may forget, and 64.7% think it is useless because waste is mixed anyway.

In this survey, the subjective norm, which considers the influence of family and friends in a person's behaviour towards the separation of their residues, is measured (Taylor and Todd 1997; Vicente and Reis 2008). The Bellavista community is not necessarily influenced, 36.7% said that they have never talked about their waste management habits, and the people who have, say that only 26.6% said that if a family member is environmentally conscious and active, then they would start to separate their waste.

It is relevant to mention that 30% of the respondents do not spend money on fertilisers and are not willing to contribute economically with the compost plant in

Bellavista, and 23.3% spend more than $400 pesos[7] in fertilisers per year, but when they were told that they could receive free compost and asked if they were willing to pay an amount per year, only 13.4% said they would pay from $1 to $300 MXN[8] pesos per year.

It was also very important to know to what degree some mechanisms could convince the neighbours to participate in the separation of their waste. The *Bellavista* neighbours pointed out that visiting the compost plant, getting information about the benefits of using compost and getting free compost are the best mechanisms to convince people to participate. On the other hand, the mechanisms that would not convince them at all were to participate in a competition of the household that separated more waste and attend to workshops about waste management.

The last question was an open one in order to know the opinion of the neighbours when it comes to suggestions to encourage community participation in *Bellavista*. One of the main suggestions was to inform through the neighbour's newsletter (56.7%) and putting different colour of trash cans outside the houses in order to make easier the organic waste collection (16.7%).

12.4 Comparative Study

The purpose of comparing the three schemes is to get to know the conditions, drivers and barriers of the compost plant created through community participation and specifically in residential areas. These analyses are in Tables 12.1 and 12.2.

Table 12.1 summarises the answers of compost plant managers concerning the drivers that led to the creation of their existing compost plant. This is relevant because although the scales of the composting programmes are diverse, the drivers are similar. In the Netherlands, it is prohibited to use landfills; the only exception is when the production capacity for incineration is exceeded. Most of the cases have in common that the programme started in order to reduce the amount of waste sent to landfills; only in the case of *Bellavista*, the driver was to stop using chemical fertilisers in the maintenance of the green areas.

The second driver that stands out is producing compost instead of buying it. This has the benefit of saving money, so it is considered an advantage. In the United Kingdom, they consider it a main driver because they explained that during the World Wars, they did not have food, so they had to grow their own food, and with the organic residues, they produced compost.

The third driver is to reduce the use of chemical fertilisers, which is the main driver for the Bellavista case, but not for the other three cases, although the compost produced in Twence is certified as a soil improver, and it is considered that the use of chemical products just damages the soil.

[7] Equivalent to $31.74 USD (exchange rate: $12.6 pesos per USD in July 2010)

[8] Equivalent to $23.8 USD (exchange rate: $12.6 pesos per USD in July 2010)

Table 12.1 Analysis of drivers to implement community compost plants (Own contribution)

Compost plant	Reduce waste in landfill	Legal incentives	Main reason to reduce the use of chemical fertilisers	Composting as an alternative to buying new compost
Case 1: Residential Area Club de Golf Bellavista, State of Mexico	Not a main objective or motivation	No legal incentives or fines	Main motivation	Not a main driver, but it is considered an advantage
Case 2: Puerto de Chivos, Atizapan de Zaragoza, State of Mexico	Main objective of the programme, although there are no legal sanctions for land filling waste	No legal incentives or fines	It is not considered a driver	Not a driver, just a consequence of doing the compost, although it is not enough for all the green areas in the municipality
Case 3: United Kingdom (Community Network)*Greenway Consulting *Brighton Community *Lower Slaughter *Cwm Harry and Trust*Denton Parish Council	The UK measures how much waste was kept from going to landfills	No legal incentives to do community compost. Just agreements with local authorities	They do not consider this a driver for the community to participate	They consider this a main driver
Case 4: Twence compost plant in Hengelo, Netherlands	Strict regulations Tax payment to use landfill	Yes, legal incentives present	They consider that the compost is very important in order to improve the soil, whereas the chemical fertilisers just damage it	The compost plant from Twence even pays farmers to get their compost

The legal incentives do not work in all cases, only in the Netherlands. Since there is no mechanism to encourage the creation and continuity of composting programmes, it becomes difficult to compel the performance of these programmes. The Netherlands fines the householders that do not separate their waste.

Once the drivers are known, it is vital to analyse the necessary conditions in which a composting programme works. The conditions could also represent a barrier for the implementation of such a programme. Table 12.2 analyses the managers' answers.

The first condition is social participation; this implies participation of the community by separating their waste and, in the case of the United Kingdom, volunteers to process the waste and the management of the compost plant. This could represent a barrier because it would be very difficult to process the waste if it is mixed with

Table 12.2 Analysis of conditions/barriers to successfully implement community compost plants

Compost plant	Social participation	Economically feasible	Infrastructure to do compost	Quality of compost under regulation	Environmental impact of the project
Case 1: Residential Area Club de Golf Bellavista, State of Mexico	The participation is low, but so its production capacity	This scheme is economically feasible, because in time compost this could be sold if there were more bio-inputs involved	The area destined for the production of compost is 75 square meters approximately; they have 2 shredders and 3 shovels	The norm NTEA-006-SMA-2006 states the compost quality standards, in order to sell it	They do not measure this in a formal way
Case 2: Puerto de Chivos, Atizapan de Zaragoza, State of Mexico	The participation is low, only 28% of the residential areas in Atizapan de Zaragoza are included in the programme, from which only 64% separate their waste	Not feasible; it is more expensive to produce compost than to landfill all the waste	They have enough space to grow in production capacity, but they currently lack infrastructure to process all the organic waste from the municipality	The norm NTEA-006-SMA-2006 states the compost quality standards, in order to sell it, but they do not do chemical analysis of the compost produced	There is no measurement or report of the environmental impact of the compost plant 'Puerto de Chivos'
Case 3: United Kingdom (Community Network) *Greenway Consulting Scotland. *Brighton Community Compost Centre. *Lower Slaughter Community Composting. *Cwm Harry and Trust *Denton Parish Council	Important but not vital because they use other green waste from pruning	It is important to be feasible, but not a requirement because in some cases they get paid to treat the organic residues instead because they avoid to send it to the landfill	Each community compost has the space necessary to produce compost, and the proper machinery to do it, close from the community	The norm PAS 100:2005 states that the specification of composted materials in order to be able to sell it. If they do not have a certification, the compost will be considered waste	They do not measure this in a formal way. They quantify how much organic waste they receive, and that it is kept from going to the landfills

(continued)

Table 12.2 (continued)

Compost plant	Social participation	Economically feasible	Infrastructure to do compost	Quality of compost under regulation	Environmental impact of the project
Case 4: Twence compost plant in Hengelo, Netherlands	Vital. The compost cannot be produced if people do not separate their garbage	The process itself is feasible because they process waste through an industrial scale and they get paid to process organic waste, but they cannot sell it yet	The infrastructure used in Twence was created to have the capacity to produce compost with organic residues of the Twence region	They have certifications like BRL Keurcompost: branche eigen certificaat compost and BGK: voor de afzet van compost in Duitsland	They measure their gas elaborate and make annual reports

inorganic residues and the costs could increase to separate every single organic residue.

The economic feasibility is an important aspect because, if it is not profitable, the programme has to stop. Although the case of *Atizapán de Zaragoza* is not profitable, they have to produce the compost because it is an obligatory programme.

The third condition is to have the proper infrastructure to process all the organic waste, and, in every case, it is considered as a must.

The next condition is that the compost should have quality standards stipulated in the regulation of each country. In the case of *Bellavista* and *Atizapán de Zaragoza*, there is a norm that states that in order to sell the compost produced, it has to be analysed and satisfy the chemical characteristics. *Bellavista* has analysed its compost once, in April 2010, but the government of Atizapán de Zaragoza, who handles the compost plant, has not done any chemical analysis. This could represent a barrier in order to market the compost. The Twence and United Kingdom cases also have to certify their compost because if not, it is considered waste.

The fifth condition is to have an assessment on the environmental impact of each programme. Most of the cases do not have a formal report on their environmental impact. The only assumption is that it is positive because less waste is taken to the landfill. In the case of Twence, each year they present a report on the gas emissions of the composting process because it is a legal requirement to do so.

These conditions are taken into account in order to transfer the community compost scheme to other residential areas in Mexico, starting with the municipality *Atizapán de Zaragoza*, and build a composting network. The direct benefits go to the community: they receive compost for their gardens, and it represents savings for the neighbours' association, as seen in the Bellavista case.

12.5 Conclusions and Recommendations

As seen before, there are two different international schemes that could contribute to suggest how to handle Mexican waste management. The Netherlands presents an top-down perspective and the United Kingdom a bottom-up perspective. It can be said that Mexico is not yet prepared to adopt Dutch approach. Even further, it is rather proposed to analyse a bottom-up approach that starts in a community compost plant in *Atizapán de Zaragoza*, where the organic residues are taken to be handled, and the rest are taken to the landfill *Puerto de Chivos*.

As a result of the comparative analysis in Sect. 12.4, it can be concluded that there are some similarities among the countries of the Netherlands, Mexico and the United Kingdom in some of the legal, social, economic, environmental and operative aspects, which are recognised in this research and mentioned in order to point out if they represent a driver or a barrier for the implementation of community compost plants.

The first aspect is the legal framework, which was addressed through the additional research question "What are the existing legal frameworks in all three countries that permit this sort of small scale projects?" The response is that in Mexico and the United Kingdom, a small-scale composting programme is not regulated nor prohibited; meanwhile the local government's programme for the composting of organic residues does not work correctly because of the lack of dissemination and enforcement in the case of Mexico; and in the United Kingdom, this way of treatment is not allowed because some organisations consider that it is not sanitary to make compost out of animal byproducts. As a result, this research suggests the creation of community composting programmes, this based on the analysis of both cases.

In the Dutch situation, there is a legal framework that establishes every residue should be reused, recycled and treated before it goes to the landfill. The programmes work because householders separate their waste, otherwise they would obtain a fine. In Mexico and the United Kingdom, at the time this research was carried out, there were no incentives (positive or negative) to start segregating waste from householders.

An aside research question is related to the social aspect of stakeholders. In Mexico, the main stakeholders are the neighbours living near the compost plant, whose main driver was to use less chemical fertilisers and therefore decrease the damage to human health. It is important to know that for the continuity of this programme, there is a neighbours' association, which manages the collection and waste treatment.

In the United Kingdom's cases, volunteers are in charge of producing compost, but there is always a group of citizens who manage the project in order to ensure the success and permanence of these programmes.

In the Netherlands' case, there is a combination of public and private stakeholders because waste collection is done by the local government, but waste treatment is done by a private company. The investment is both public and private, which ensures

the permanence of the programme. It is important to mention that due to the composting system size, the comparison between the Dutch system and the two others of this research was not possible.

It is also important to consider that with the purpose of implementing a successful compost plant like Twente, citizens' participation by separating their waste is vital, and the employees must be trained. All the stakeholders have an important role, but when it comes to the implementation of a composting programme, the management is the key to give permanency to such programmes. And such lesson can be extended somehow to the communitarian composting plants in Mexico and the United Kingdom.

In order to respond the research question mentioned in the abstract, an additional question was formulated: "What were the main actors' motivations and incentives to engage the composting plant in the community in order to process organic waste?" The main motivations found in all the case studies were that by engaging in composting organic waste, less quantity of residues is sent to the landfills, and less money is spent in buying fertilisers, because the compost produced can be used as a natural fertiliser, and it also can be sold when its quality is proved.

The question to address the social, economic, environmental and operational variables was formulated as "What are the differences and similarities in terms of standards for the socio-economical-political-cultural contexts among the three countries?"

The role of political actors in public administration does not influence the waste management schemes of the Netherlands and United Kingdom, since Twence (NL) is a combined system (public and private) governed by market forces. While in the UK waste management is done through community organisations, they have independence and continuity despite changes of government. This situation is not given in the Mexican context, as landfills and local compost plants' management is centralised and managed by municipal governments. This difference in management may represent an incentive in the implementation of community composting, which would give them autonomy and continuity to the project.

The variables considered for the analysis of conditions for the successful implementation of a compost plant were social participation, economic feasibility, infrastructure to do compost, quality of compost under the regulation and the environmental impact of the project. These could constitute a condition or a barrier that could intervene in the success of a composting programme.

The first variable is the social participation; this is vital because if the community does not separate their waste, the raw material for the elaboration of the compost could be polluted with other sorts of inorganic material, and as a consequence, the quality of the compost diminishes. It is also important to mention that in Mexico, there is an issue concerning the environmental culture because there is a perception that even if citizens separate their waste, it would be mixed again, which is why the composting programmes do not work.

The second variable is the feasibility of the programme. Most programmes sell the compost produced (UK and NL) or make agreements with the local government to get paid for treating the organic waste instead of sending it to landfills (UK and

NL), and in the Mexican cases (Puerto de Chivos and Bellavista), they use the compost in green areas instead of fertilisers, which produces savings. The fact that the compost produced can be sold and the situations mentioned above makes a compost plant feasible.

The third variable is the infrastructure to produce compost; the minimum requirements are a space to produce compost and store raw materials, shredders and shovels. The quality of the compost is also measured in each case, and it is considered an aspect that is important in order to sell it. The last variable is the environmental impact of the project, which is not evaluated in small-scale waste management, only in Twence, because it is legally established in Netherlands, although it is important to propose this evaluation in each case studies.

The final question is related to the operational aspect: "How does the project management contribute to the permanency of community composting plants?" The main answer was through formalising the organisation that operates the community compost plant, with clear roles and responsibilities of each member who participates in the management of the community compost.

And finally the success aspects of the existing compost plants and how they can be used as a reference to improve the compost plant in Bellavista are hereby enlisted in the form of suggestions to improve. the current residential scale model in Club de Golf Bellavista:

- In order to sell the compost produced, it has to be a high quality one, so it is important to have the compost analysed in its chemical characteristics regularly and getting an international certification to prove the quality of it as a soil improver.
- Start an awareness campaign in order to promote the compost plant in Bellavista and invite neighbours to visit the facilities.
- Elaborate annual reports about the organic waste received and processed and the resulting compost, including the economic performance.
- Organise trainings for compost plant operators.
- Approach the local government for technical and economic support.
- Inform the neighbours about the compost benefits and the way they could get free compost for their gardens through newsletters and the installations of trash cans of different colours to collect the organic waste more efficiently and start workshops.

To sum up, it can be concluded that for a community compost plant to work, there should be a dissemination of the programme. To be profitable, the composting process needs to ensure the quality of the final product in order to sell it, have a suitable production area to prevent odours and the presence of pests or vermin, as well as institutionalising the activities by means of manuals of good practices in the management of organic waste to produce compost and annual reports on its performance. With these conditions, the community compost scheme could translate to other residential areas with similar characteristics.

As a next step and a recommendation, a community compost network could be created as a support for those who start a community compost plant to share recycling best practices and technical and economic advice.

In this regard, as part of a pilot programme, the composting network could be implemented in the municipality of *Atizapán de Zaragoza*, with 153 residential areas, where there are neighbourhood associations. By doing this, 1046.52 tons per year of organic waste would not be taken to the landfill *Puerto de Chivos*. Besides, 469 direct jobs are expected to be created for the operation of the compost plants. This could also lead to an agreement with municipal authorities for the donation of land for the waste treatment process.

When the barriers of locally composting systems are overcome, the collection and treatment of USW can be replaced by one industrial composting system. Although this perspective is not currently feasible for Mexico, it is crucial to support governments to consider a more sustainable way of dealing with household waste in the long term.

Finally, some recommendations for strengthening this research are to have a more representative sample of the population and to expand the number of cases that have a similar waste management as Bellavista.

References

Álvarez AE (2002) Historia de la basura en la ciudad de México. http://www.geocities.com/camp_pro_amb/historia.htm. Accessed June 2010

Association for Organic Recycling (2010) http://www.organics-recycling.org.uk. Accessed July 2010

Bernache Pérez G (2006) Cuando la basura nos alcance: el impacto de la degradación ambiental. Centro de Investigaciones y Estudios Superiores en Antropología Social, Distrito Federal

Business and Science Park (2010) http://www.sciencepark.nl/en/location/. Accessed 22 July 2010

Castillo Berthier HG (2002) CIENCIAS 20

Community Compost (2010) http://www.communitycompost.org. Accessed July 2010

Compost Network (2008) http://www.compostnetwork.info/index.php?id=40. Accessed July 2010

Compost-it.org.uk (2010) www.compost-it.org.uk. Accessed July 2010

Cylch Community Recycling Network (2010) http://www.cylch.org. Accessed July 2010

Dennis N, Baxter A, Darwin N (2006) Potential health risks to humans from birds, mammals and insects associated with UK waste management operations: A literature review. Bird Management Unit, United Kingdom

Forrester Germeshausen JW (1991) System dynamics and the lessons of 35 years. Massachusetts Institute of Technology, Cambridge, MA

Forrester JW, Martin LA (1997) Beginner modeling exercises. MIT System Dynamics in Education Project

Greenway Consulting (2010) http://www.greenwayconsulting.co.uk. Accessed July 2010

Greenwichmeantime (2010) http://www.greenwichmeantime.com/time-zone/europe/uk/map.htm. Accessed October 2010

Herrera Massieu R (2004) "Cómo y por qué separar la basura. Una solución al problema de los residuos sólidos en la Ciudad de México. Distrito Federal: Servicios Industriales Peñoles S.A. de C.V. Secretaria de Medio Ambiente del Distrito Federal

Instituto Nacional de Ecología (2010) http://www2.ine.gob.mx/publicaciones/libros/499/experiencias.html. Accessed June 2010

La república (September de 2008) Se acaba el tiempo para la basura de la ciudad de México

Martinez M (2 de October de 2009) Questionnaire on Compost plant experience with community participation. (V. Plasencia Vélez, Entrevistador)

Medellin C (2015) Gestionan ampliar 15 anos mas el relleno de Puerto de Chivos. Revista Mexiquense. http://www.reportemexiquense.com/infomacion-general/gestionan-ampliar-15-anos-mas-el-relleno-de-puerto-de-chivos. Accessed July 2010

Mejia F (Mayo 2016) La basura genera 16% de la contaminación. Milenio

Ministry of Housing, Spatial planning and the Environment (2001) Legislation, waste in Netherlands. Netherlands: Directorate-General For Environment Protection

Organics recycling (2010) http://www.organics-recycling.org.uk. Accessed July 2010

Restrepo, Phillips (1991) La basura, consumo y desperdicio en el Distrito Federal. Centro de Eco desarrollo, México

Secretaria de Obras Distrito Federal (2010) http://www.obras.df.gob.mx/servicios_urbanos/residuos/rec_trans_sel_final.html. Accessed Sept 2010

Semple KT, Fermor TR (2001) Impact of composting strategies on the treatment of soils contaminated with organic pollutants. Environ Pollut 112:269–283

Slater R, Davies P, Gilbert J (2004) The state of composting in the UK. The Composting Association, United Kingdom

Taylor S, Todd P (1997) Understanding the determinants of consumer composting behaviour. J Appl Soc Psychol

Twence (2010) http://www.twence.nl/en/over% 20twence Accessed June 2010

Universidad Autonoma de Guadalajara (2010) http://www.uag.mx/27/genetica/gpos.htm. Accessed Sept 2010

Vicente P, Reis E (2008) Factors influencing households' participation in recycling. UNIDE, Department of Quantitative Methods, 140–146

Villegas A, Franco R (2010) Exploratory Questionnaire to responsible of composting process in Puerto de Chivos, Atizapan de Zaragoza. (V. Plasencia, Entrevistador)

VROM (2010) Recovered in July de 2010

Waste Online (2005) http://www.wasteonline.org.uk/resources/InformationSheets/Compost.htm. Accessed June 2010