2005:MV04

UNIVERSITY WEST

# A COMPARATIVE STUDY OF WASTE COLLECTION SYSTEMS IN MEXICO AND SWEDEN

**Nancy Contreras Valenzuela**

**BACHELOR'S THESIS**
**Department of Technology, Mathematics and Computer Science**

## Acknowledgements

This thesis is my final report from my studies in the Environmental Science program at the University West. This report is a comparative study of two different waste collection systems, Mexico and Sweden. The report was made in Mexico and Sweden from April to October 2005.

I would like to thank my instructor Claes Fredriksson from University West, for his support, understanding, patience and criticisms during this project.

I wish to thank Anabel Martinez from El Colegio de Mexico, for all the information and sharing of knowledge I get during my visit to Mexico City.

Furthermore, I want to thank the organisations for the information I get kindly in Cuernavaca as: CONANP, SEMARNAT and The Public Cleanising at the Environment Department in Cuernavaca.

Nancy Contreras

Trollhättan, Sweden 2006

*BACHELOR'S THESIS*

# A comparative study of waste collection systems in Mexico and Sweden


## Abstract

The purpose of this project is to describe and compare two different waste management systems in two countries.

Soil and water contamination by waste is one of the biggest environmental problems nowadays. For developing countries waste contamination has become an important problem. This because the lack of manage and efficiency in the management of waste system.

Through compare one developing and developed country can we see the reason of why the success of one system or another.

I choose Mexico because waste is one of the biggest environmental problems that the country faces with nowadays. Mexico's large population and the increasing demand of natural resources to produce new products have lifted the consumption pattern with a result of an incresment in waste production.

Sweden has had a waste management since 20 years ago and with the introduction of new laws has the management developed continuously. Sweden's experience in waste management can be therefore a good reference at the comparison of waste systems.

What I observed during my visit in Mexico and what I have investigated, Mexico still has a long way to success with the management of waste system. Mexico has changed some laws for more environmental friendly ones, but still the management and the application of those are still far from become a reality for the country. For at Mexico's waste program can succeed is necessary the connection between the three political levels. The lack of interest from government and local politics has not helped in the development of the waste management system. Mexico needs more environmental education to the population but also needs politicians that are interested in the conservation of the environment.



| | | | |
|---|---|---|---|
| **Author**: | Nancy Contreras Valenzuela | | |
| **Examiner**: | Jonas Hansson | | |
| **Advisor**: | Claes Fredriksson | | |
| **Programme**: | Environmental Sciencie | | |
| **Subject**: | Study of waste collection system | **Level**: | Bachelor |
| **Date**: | June, 2006 | **Report Number**: | 2005:MV04 |
| **Keywords** | Waste collection system, waste management, comparision between Mexiko and Sweden | | |
| **Publisher**: | University West, Department of Technology, Mathematics and Computer Science, S-461 86 Trollhättan, SWEDEN<br>Phone: + 46 520 22 30 00 Fax: + 46 520 22 32 99 Web: www.hv.se | | |

## List of symbols

| | |
|---|---|
| LGEEPA | The General Law of the Ecological Equilibrium and the Protection of the Environment |
| LGPGIR | The General Law for the Prevention and Integral Management of Waste |
| GIRSM | The Manual for municipal waste management |
| NOM | Mexican Official Standard |
| PROFEPA | The Office of the Attorney General for Environmental Protection |
| SEMARNAT | Secretariat of the Environment |
| CONANP | National Commission for Protected Natural Areas |
| SEP | The Secretariat of Public Education |
| CECADESU | Education Centre for the Sustainable Development |
| NAFTA | North America Free Trade Agreement |
| INE | National Ecology Institute |
| NATURVÅRDVERKET | Swedish Environmental Protection Agency |
| RVF | Swedish Association of Waste Management |
| IVL | Swedish Environmental Research Institute |

## Contents

# 1 INTRODUCTION

The problem of handling waste in developing countries is enormous. Most of these countries do not have economic resources to combat such problems as developed ones do. Developed countries have technological alternatives which poor countries lack. In order for a nation to develop technologically, a stable economy is required.

The last four decades, both the economy and the population have grown. One of the environmental problems that Mexico is facing nowadays is the huge production of waste and the final disposal of it (Chárraga, 2003).

In the late 80's Mexico initiated its environmental work and since then environmental policies and new regulations, as well as laws have been implemented. Ley General del Equilibrio Ecológico y la Protección Ambiental (LGEEPA) was one new law created in 1988 to define responsibilities and legal environmental actions of the government.

In 1992, Mexico signed the convention of sustainable development and biodiversity in Rio de Janeiro. New reforms and organizations were created to carry out what was proposed in Agenda 21. The environmental politics began to change when Mexico accepted to stop the environmental deterioration.

Since Mexico became a part of the North America Free Trade Agreement (NAFTA) which came in force in 1994, Mexico had to make changes in order to diminish industrial impact on the environment. Industrially produced waste and so called "hazardous waste", are part of the enormous problem of waste management in Mexico (Graizbord, 2004).

During the last decade, the waste problem has grown due to urbanization. The growing economy also gives room for increased consumption. This means that the amount of waste is growing in the cities. In most of the Mexican cities, the waste management is not capable of handling the annual increase.

During the current presidential period (2000-2006), new strategies for waste management were introduced. In 2003, a new legislation was approved with specifications on construction, design, location, operation and monitoring of the final disposal of waste. Waste management in Mexico is still in the process of development and each region has to develop its own system to handle their waste problems.

Management of industrial waste has stimulated the development of a better system to meet the growing need for capacity. It was due to industrial accidents that the government began federal legislation, but also because of the growing number of industries in the U.S border area.

Since 1979, Sweden has introduced laws referring to waste management and after the oil crisis in 1973 they have also worked thoroughly in the development of renewable energy. This should not only be environmentally friendly but also be enough to produce energy throughout the year. The production of garbage is increasing in every city and the volume is considerable. Since many years, the incineration of waste in order to produce energy is one of the strategies that Sweden has developed in order to manage waste and energy problems. The use of organic municipal waste to produce biogas is a growing source of renewable energy. Sweden not only has the technology to manage the waste problems but also has an efficient system of collection of waste.

Mexico is a country in development, with large cultural, environmental and socioeconomic differences compared to Sweden. Mexico began with waste management very recently, while Sweden has a rather long history of efficient waste management.

This Thesis will focus in the differences between two diverse systems and how they function. It is divided in three parts. The first part describes the current situation of the waste management in Mexico, the second describes Swedish waste management systems and the third part is a comparative analysis investigating the reasons for the differences between the countries.

## *1.1 Purpose and goal*

The purpose of this work is to study different Mexican and Swedish waste collection systems, and investigate the infrastructure that each country is using to solve the waste problems, including energy retrieval from the waste. I describe the environmental laws that regulate both countries and Mexico's difficulty to develop a proper waste management is discussed and an analysis is made of the economic and social situation that Mexico meets when trying to obtain an efficient waste management. One of the goals of this study is to describe the informal recycling system which is being carried out unofficially by people in Mexico. Recycling and Reutilization are considered to be important and interesting characteristic aspects and are therefore emphasized.

## *1.2 Methodology*

I travelled to Mexico in mars 2005, in search for information and also to observe how the system actually works. The waste management system is designed and operated by each Municipality. The study and interviews were made in Cuernavaca, state of Morelos, situated in the centre-south of the country. These interviews were carried out with government employees of the state of Morelos. Furthermore I interviewed Anacleto Pedraza, spokesperson from the political

party Partido Revolucionario Democratico (PRD) who is in charge of environmental issues.

To investigate how the Municipality organizes the waste collection system, an interview with the Director of Public Cleansing at the Environmental Department of Cuernavaca David Garcia Castañeda was made.

I visited the transfer centre, where all collector trucks leave the garbage and took the opportunity to interview the workers. Each collector truck leaves the garbage in a big container which is later transported for the final disposal. The final destination for the waste from Cuernavaca and other municipalities is the landfill of Tetlama. During my visit to Tetlama landfill, I could observe how the employees performed the task of recycling plastic, metals and cardboard.

While in Cuernavaca, I interviewed the street workers concerning their job and their work with recycling of materials.

The Secretariat of the Environment (SEMARNAT) is a governmental organization whose work consists of carrying out new ecological policies in order to protect and preserve the natural resources of the land. The SEMARNAT works very closely with other institutions, such as universities and investigation centres. El Colegio de Mexico is one of the institutes that collaborate with SEMARNAT. In El Colegio de México I had a broad interview with Anabel Martinez, 15th April 2005, a researcher on the subject of municipal and industrial waste management in the North of Mexico.

## *1.3 Limitations*

The waste collection in Mexico can not be described as one system. In Mexico, it is the municipality who is responsible for the waste collection and its final disposal. The collection of waste is varying from one state to another, depending on the political, cultural and economic resources and possibilities.

Only a few waste collection systems are being described in this document. These places are situated on the northern states of Mexico, Mexico City (the capital) and Cuernavaca.

In the northern states of Mexico, studies from El Colegio de Mexico and SEMARNAT have recently been carried out regarding waste and environment. There was no access to information from the rest of the states. Consequently, I describe only the waste management systems of Mexico City and Cuernavaca, from where all the field studies and information were obtained.

## 2 WASTE MANAGEMENT IN MEXICO

Only a few states in the country have initiated projects to develop new systems of municipal waste collection. The Constitution stipulates that waste collection is free of charge for the municipalities but a few cities have implemented payment for this service. Still, these fees are not enough to solve the economical problems that the waste management has. According to the National Ecology Institute (INE), Mexico's municipal waste production is estimated to be approximately 80,000 tons/day in 2002. This means 30 million tons of municipal waste each year, throughout the country.

The waste collection systems in almost all the cities in Mexico are inefficient and it is estimated that only 80 % of the waste is collected. Approximately 50 % of the municipal waste is deposited adequately. The rest of the waste is burned in the backyards of private houses in small villages; thrown out on the streets or abandoned in rivers, causing flooding of rivers in the cities.

The average waste generation per capita in Mexico is 1.13 kg/day in 2005. This figure varies from city to state depending on the economical activity and social level. The cities of the north and Mexico City have a higher generation per capita. The figures were estimated after an investigation of the composition and generation of the municipal waste in Mexico made by INE 1999. According to Chárraga and Provencio 77 % of the waste is domestic and 23 % comes from other sources, such as, offices, stores, shops and small industries.

Mexico is divided into five regions which are called border, north, centre, occident and south. An estimation of the waste generation per capita 1997-2005 are shown in Table 1.

***Table 1. Generation of waste per capita (kg/day) for the years 1997, 2000 and 2005. Source: INE 2004***

| Region/year | border | north | centre | occident | south |
|---|---|---|---|---|---|
| **1997** | 0.92 | 0.85 | 0.95 | 0.86 | 0.89 |
| **2000** | 0.96 | 0.94 | 1.15 | 0.91 | 0.98 |
| **2005** | 1.05 | 1.03 | 1.27 | 1.00 | 1.07 |

The content of the municipal waste, is 14 % paper and carton, 4 % plastic, 3 % metals, 1 % textile, 6 % glass, 53 % organic matter and 19 % others. (See Figure 1). In 2001, only 28 % of all Mexico's municipal waste, it means that 9 million tons/year, was recycled. Only 8 % of all this recycled waste was

processed. The recycling of batteries is not common, but in some cities it is promoted (Graizbord, 2004).

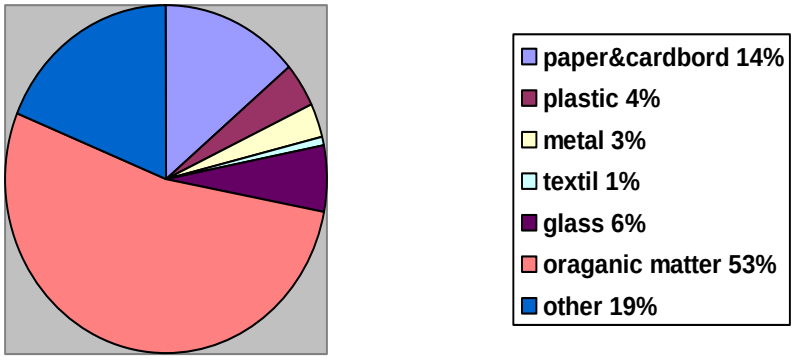


***Figure 1. The most common waste in Mexico. Source SEDESOL, Mexico 2002***

In the cities of the north, the management system efficiency reaches 95 %.

In this region the waste collection is adequately disposed in an 80 %. An average of 20 % of the waste is not collected and it's dumped in the streets or rivers.

Landfills are the main option for final disposal of waste in Mexico. The 77 landfills in Mexico managed about 19 million tons/year in 2001, which is about 60 % of the municipal waste. Only 4 of them are handled adequately. The uncontrolled landfills accumulate more than 3 million tons/year, which means that 40 % of the municipal waste, *i.e.*12 million tons, finishes in open sky landfills. Among these, one million used tyres are included that usually are dumped in controlled or uncontrolled landfills.

The Manual for Municipal Waste Management in Mexico (GIRSM) came out in 2003. Within a series of programs, guidelines to the municipal authorities to design waste management system in each city is specified. To reach the goals, the municipalities should consider the reutilization, recycling, collection, treatment, storage, separation and final disposal of waste**.**

Environmental education in the schools is a major project in Mexico and success is needed. CONANP is one governmental organisation that has diverse environmental education projects in schools and in small communities. The environmental education project driven by CONANP is based on Mexico's environmental standards.

## *2.1 Laws and environmental regulations*

During two decades between 1940 and 1960, Mexico built its economy and the government decided to invest in the industry (Micheli, 2002). The industry grew very fast in big cities and a new labour market began to develop. Most of the manufacturing and chemical industry was situated around the borders or in the capital city. Many of these industries made use of raw materials in which the natural resources were intensely and extensively exploited without any concern for future environmental damage in the country. The government had no policies regarding the management of waste, emissions to air and/or water and while the urbanization was growing, the depletion of the natural areas was decreasing.

Environmental politics in Mexico took off in the 80s-90's. International trade made the country initiate new environmental policies. Mexico was going through an environmental crisis and it needed to introduce new regulatory laws to start environmental programs in the country (Micheli, 2002).

The 70's brought an idea of what an environmental crisis meant to the economy and the nature. From the seventies and until 1984 there existed only one law that referred to environmental pollution. This was The Federal Law of Control and Prevention of Pollution, issued in 1971. The sub agency of environmental improvement was in charge from 1972 until 1976.

It was not until the 80's that the environmental problem was acknowledged in the political agenda and laws were created to address the severe environmental problems in the country.

To solve the environmental problems, the authorities created new organizations. The Ministry of Urban Development and Ecology (SEDUE), was subsequently created to monitor the compliance with the laws.

During Miguel de la Madrid's presidential period between 1983 and 1988, the so called National Plan of Development started. This was the first time that environmental topics were included in the political agenda, being appropriate to the country's political development. Other important points that were included in this plan were the use of the land, new technology and the prevention of the increasing population.

In 1983, the government reformed article 15$^{th}$ of the National Constitution that declares that all economical activities that require usage of natural resources should ensure the conservation of those (Micheli, 2002).

In the mid 80's, manufacturing industries in the north of Mexico and the United States signed an agreement for the protection and improvement of the environment around the border between these two countries.

The "maquiladora**"** industry in the north of the country is one of the biggest manufacturing businesses in Mexico. Because of this, the low cost in labour and that environmental laws and regulations were not yet in place, many international companies from United States and elsewhere moved to Mexico in the 80's. The cost of ecological damage was not as high as in the United States.

An amendment to the 1st. Article of the Federal Constitution was introduced in 1984. This amendment was used to establish regulations in order to protect the environment.

The LGEEPA was introduced in 1988 in order to preserve, restore and protect the environmental equilibrium.

The reform included the collaboration between the three levels of politic authority which are Federation, State and Municipality. Two of the Federal articles in the Constitution changed after the LGEEPA. These are articles, number 27 and 73, which allow the faculty of the congress to introduce environmental legislation. Simultaneously with the LGEEPA, 31 other state laws were created, one for each state, and 5 regulations in the areas of: evaluation of environmental impact, air pollution, hazardous waste and the transport of them.

In 1992, Mexico participated in and signed the Rio declaration of sustainable development. After this event, Mexico introduced new policies that focused on sustainable development. The country needed to change its attitude, towards the environment, and understand the connection between the economic, social and ecological development. During the presidential period from 1988 to 1994, Mexico started building new organisations with the responsibility of inspecting the enforcement of laws and regulations. In 1992, the National Ecology Institute (INE) and The Office of the Attorney General for Environmental Protection (PROFEPA) were created. PROFEPA is still in charge of following up the fulfilment of the laws.

During this period, the country began an era of neoliberal politics and new economics markets moved towards Mexico (Micheli, 2002).

The new markets demanded environmental regulations before they got started in the country. An example of such a market was NAFTA between Canada, United States and Mexico. The agreement came in force January 1st, 1994. Since the joining of NAFTA, the government made efforts to regulate and control the hazardous waste production and management. This and other changes led to the reformation of the environmental law, LGEEPA in 1996.

During the presidential period from 1994 to 2000, drastic changes in the environmental politics occurred in the country. International laws and business

certification were the main political topics during this period. In this period, the environmental agency SEMARNAP (nowadays called SEMARNAT) restarted. Its work which was focused mainly on sustainable development and all efforts were concentrated in sustainable production and reduction of environmental damage. To prevent and diminish industrial wastes as well as to prevent accidents, a new strategy was taken in 1995 concerning hazardous waste. This recognizes the severe industrial waste problems and the necessity for industrial regulations. In 1996, a reformation of the LGEEPA environmental law was necessary to define sustainable development, as well as to emphasize the necessity of regulation and standards. New environmental laws have been introduced since then and one of them is about waste management, The General Law for the prevention and Integration of the Solid Waste (LGPGIR 2003). Four other laws have been modified and three are in the progress of approval. The law of renewable energy is still in process. In addition to the new reforms, ecological standards were also reformed within Official Mexican Standard NOM-ECOL, being reduced from 82 to 46. One of them is the reformed standard of NOM-083-SEMARNAT-2003, which specifies the protection of the environment in the selection of the location, design, construction, operation and monitoring of municipal and industrial waste. The way that Mexican standards are used to regulate and control the environment, works very similar to that in the United States, but the Mexican is still being developed (Graizbord, 2004).

## *2.2 Waste collection systems in Mexico*

According to INE (Chárraga and Durazo, 1999), the systems of urban cleaning are divided into five areas:

1. Cleaning of public areas
2. Collection systems
3. Transfer centra
4. Treatment plants
5. Final disposal

### *1. Cleaning of public areas*

The cleaning activities are carried out by manual and mechanical methods. Manual methods are actually used to clean sidewalks, parks and squares in almost all the cities in Mexico. This work is done by garbage collectors who, afterwards, sort the garbage before loading the containers. Mechanical methods

are often used in big avenues. The number of mechanical cleaners varies depending on the budget of each municipality.

### *2. Collection systems*

A collection system has the function of compiling garbage from where it is generated (houses, schools and offices) and storing it until it is left in transfer centra or landfills. In most of the municipalities, the administration shares the service with private collection companies. The municipality operates trucks and trailers, but usually the vehicles are old and inadequate. Some of the vehicles are not made for this kind of activity and can harm the environment and provide bad working conditions for the garbage collectors. The collection of waste offers an efficiency indicator in the Mexican management system. This indicator specifies the percentage of the population that has the service of collection of waste in a particular area (Graizbord, 2004).

There are different methods of waste collection. Corner or permanent stop is the most commonly used. The trucks announce their stop with a signal. Generally, there are two garbage collectors in each unit. These usually receive some tip from the people. Occasionally, there are more than two garbage collectors in the unit and their work is divided between sorting garbage and selling the recyclables. The trucks transport the waste to the transfer centre, treatment plants or final disposal. The efficiency of the waste collection is about 78 % in all the country. Domestic waste storage is ineffective and therefore, problems often occur during the collection. An important aspect of temporary waste storage in public areas, such as streets, parks or squares, is that the containers are not always available or even lacking. Furthermore, the collection of them is not always made regulary. This situation has resulted in small dumps around containers, causing proliferation of disease and an unpleasant environment in the city. After the participation of private companies, it was possible to find containers of appropriate sizes and capacities (Chárraga and Durazo, 1999)

### *3. Transfer centra*

The long distance between cities and landfills has made it necessary to build transfer centra. This is often located in medium sized cities that develop important economical activities but where it is difficult to find a proper place for the final disposal of the waste. The waste is transported from the transfer centra to the landfills in trailers with a capacity of 15 to 25 metric tons. Some transfer centra have made environmental improvements, but it is far from true that all the transfer centra in Mexico are fulfilling their environmental requirements.

### *4. Treatment Plants*

Incineration, recycling of sub products and production of compost is not successful in Mexico. The reason is that many of them have been closed due to high operation costs and deficient production of the final product. The first large compost production plant was started in Toluca in 1969. Subsequently, another plant was built in Guadalajara in 1972. This plant had a capacity for 500 tons/day but is now closed. In Monterrey, another one that was built in 1973 with the same capacity is also closed. In Mexico City, one compost plant was installed in 1974 but was redesigned in 1990 to work only with the selection and recuperation of sub products. From 1993 to 1998 three more plants were built to solve the increasing waste problem in the city. Currently, the treatment plants in Mexico City have the capacity to handle 6,500 tons/day.

Two states have begun to build treatment plants with the purpose of recuperating primary materials for the recycling industry and increase useful life time of the landfills. Only in Monterrey, biogas from landfills is used as an energy source.

### *5. Final disposal*

The final disposal in the best examples are the sanitary landfills where there is adequate infrastructure to avoid harmful effects on the environment. The different methods used in the landfills are combined area and trench, where the solid waste is deposited, compacted and subsequently covered with a layer of soil. The final disposal of approximately 50 % of the solid waste is made in open sky landfills (Chárraga and Durazo, 1999). The other 50 % is deposited adequately in sanitary landfills. There are 40 sanitary landfills in the country that are distributed among 9 cities (Chárraga and Durazo, 1999).

To describe how the current collection system works, I choose three regions: two in the south and one in the north. Mexico City, one of the biggest cities in the word, because it's importance as a capital. Cuernavaca since it was the base of the visit and the north region because it's one of the biggest regions in the country.

## *Mexico City*

In Mexico City, the population is more than 20 million people, with highly diverse social, educational, economic status. Rural and industrial activities also cause a cultural diversity. Because of these differences, a large polarisation in the population is evident. The rapid and enormous growth of the city has caused many environmental problems. One of them, that affect the biodiversity, is the lack of natural resources. Accumulation of waste, air and water pollution are

some of the main problems that the largest cities in the world are going through. The generation of waste and bad management of it has increased in the past 50 years because of the growth of the population. The generation per capita was 370 kg/day in 1950 and 1.4 kg/day and in 2002 (Quadri and Wehenpohl, 2003).

The total generation of waste in Mexico City is 12,000 tons/day in 2002. 50 % is domestic and 30 % is from offices, industries, hospitals and 10 % from other sources as is shown in Figure 2. The composition of the waste in Mexico City is 50 % organic, 34 % recyclable and 16 % of residues. 10 % units out of the 34 % of the recyclable waste is recovered in the treatment plants (Quadri and Wehenpohl, 2003).

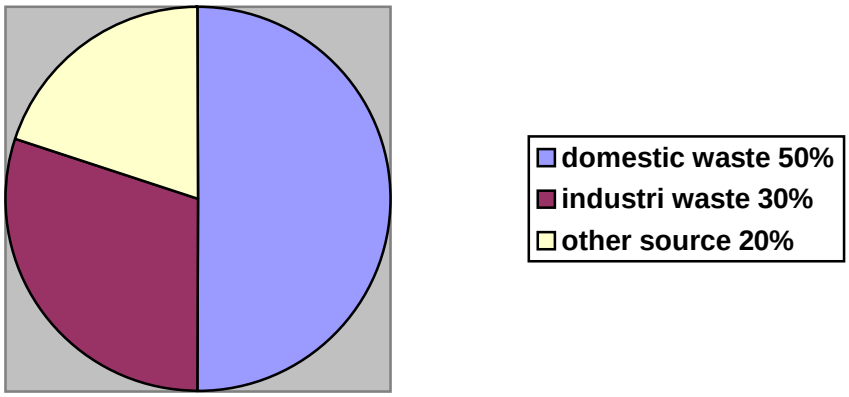


***Figure 2. Mexico City's division of waste. Source: Chárraga, 2003.***

After the LGPGIR legislation in 2003, education has been a good tool for the government to motivate the community in participating in the project of waste management. That is why the schools have become a strategic complement this project, manifested in Crossed National by a Clean Mexico. This project started by SEMARNAT was motivated by Agenda 21, where the target is to promote separation of waste in houses, schools and at work. At the beginning of the project, only the schools of Mexico City were covered, but the target was that all the schools in the country should participate.

In Mexico City, the waste from schools, houses, hospitals and streets is collected in trailers, with a capacity of 5 tons. It covers 86 % of all waste collected in the entire city. Mexico City generates 12,000 tons each day, as mentioned above, but only 9,800 arrive to the 13 transfer stations. Only 6,500 are taken to the selection plants.

In apartment buildings, garbage is often collected in plastic bags or 20 litre cans. The trailer comes around twice a week and residents take the garbage

directly to the collectors. There are also containers in some areas of Mexico City were the inhabitants can throw away their garbage directly. The garbage from the streets is collected in plastic 50 litre cans but also in containers divided into fractions where the garbage is separated. This kind of container has a different colour for each fraction: green is for organic, grey is for recyclable and orange is for other garbage. The pots are also situated in central stations, shopping malls, and schools. Normally, people do not throw their garbage in the right compartment. My observation was that some people do not know the difference between organic and inorganic, but there are also people that know about the differences and still do not put garbage in the correct place.

When the trailer is full, the waste is transported to one of the 13 transfer stations where later trailers with a 20 ton capacity transfer the waste to any of the three sorting plants.

In the sorting plant, the materials are manually separated for recycling. These plants have 1,500 employees working three shifts and they can handle about 6, 500 tons of garbage per day. The rest of the waste is transferred for final disposal in the Bordo Poniente landfill. An important remark is that about 750 tons/day are found in public areas, for example streets and parks.

Bordo Poniente is one of the largest landfills in the world and it is located were lake Texcoco was before. The landfill was opened in 1985 and in 1992 the three first sections were covered. This landfill will be useful until 2007.

According to the manual of adequate management of municipal waste, the area of Bordo Poniente is 1,000 ha and the landfill works in different sections, described as followed.

Three sections are now closing because their cycle of life is over, but the fourth section has opened and it has an area of 420 ha. The first section is isolated from the ground by polystyrene of high density, which works as an impermeable membrane. To protect this membrane, 30 cm of clay is used. Between each ditch there is a distance of 12 m to have enough space for the trailers, and barriers of 1.5 m. The waste is deposited into ditches and then a layer of mud is spread over it. The two other sections are working with the so called area method. This is the latest method and here; the garbage is compacted and spread on all the area. Because the huge amounts of garbage is very common that piles reach 8.5 m high.

A plant for treatment of leach water is situated in the first section. This treatment includes acidification, neutralization, coagulation and primary sedimentation. After going through this process the water can be used to irrigate fields.

### *Cuernavaca*

Cuernavaca is situated in the centre region of the country and it is only 73 km from Mexico City. The City has a population of 1.5 million and as in Mexico City; there are cultural differences, as in almost all the cities in the country. Cuernavaca is a tourist city and it has a zone with restaurants, markets and offices.

The waste management is driven by the municipality and the collection covers only 60 % efficiency of the domestic and street collection. Cuernavaca has waste management rules in which its effect on the environment is an important part. Recently, the municipality has proposed a new program to the government to improve the waste management service in the city to up to 80 % effectiveness (Garcia, 2005). The program proposes a better management of the landfill Tetlama, which currently has insufficient management and lack effectiveness in its process. Tetlama's cycle of life is over so a project to find a new place to substitute the landfill has begun. This project will probably be a municipal landfill which will cover not only Cuernavaca, but also its surroundings. As a result of this, other landfills can be closed. The transfer centre is also bothersome, as it is situated inside the urban zone, probably causing health problems to the population (Garcia, 2005).

While the project is still in progress, Cuernavaca continues to mix garbage without separation of the fractions. The separation of fractions and the recycling is done at the landfills, where families of scavengers work everyday to collect materials that can be sold later for reutilization.

In some places, like universities, primary schools or other cultural centres, the separation of fractions has begun. The SEMARNAT, in collaboration with other organisations, has initiated environmental education in schools and in small villages outside the city. The environmental education includes separation of waste but also the importance of the environment and biodiversity.

The waste generation per capita in the city has been 1.3 kg/day and according to the department of waste management, Cuernavaca city generated 164,250 tons/year and ca 182,500 tons/year of waste in the entire municipality in 2004.

43 % is domestic waste and 57 % comes from other sources, of which 50 % is organic, 20 % inorganic and 30 % potentially recyclable (Silva, 2005).

The waste management does not work in the city. Some projects have failed because lack of communication between the municipality and the community (Garcia, 2005). As a consequence, the efficiency of the collection has been very low in the city in comparison with other cities in the country.

The waste collection in the city follows a specific daily route. Usually, in houses, the garbage is collected in plastic bags but some people prefer 20 litre cans. In big avenues waste is frequently left in the corners of each street, so that the collector truck can collect it during night time. Even though most containers have unsorted garbage, there are some that one sorted. The collection occurs only by night, as there is less traffic**.** In the city, truck collectors pass twice a week**.** The collection of waste in restaurants and offices occur several times a week. Usually, they pay for the collection and the price varies depending on the type of waste and the frequency.

The collection is carried out by 38 vehicles, with a capacity of 5 tons each. After the collection route, the waste is transferred to the only transfer centre in the city. In this centre, trailers with a capacity of 40 tons, transport the garbage to the landfill twice a day. The transfer centre receives 194,607 tons/year from Cuernavaca as well as from other cities (Garcia, 2005).

Tetlama landfill is situated 31 km from Cuernavaca. According to the municipal waste program, it is estimated that Tetlama receives 201,597 tons/year but not only from Cuernavaca but from four other municipalities: Zapata, Xochitepec, Jiutepec and Temixco. Landfill Tetlama has problems to keep up with the waste volume that comes each day. Tetlama is a controllated landfill. Only a few tractors spread and compress the waste. A lot of scavengers work everyday in Tetlama, gathering when a trailer from the transfer centre comes. When the trailer leaves the garbage, the scavengers collect recyclable material which is later sold.

Scavengers sell the materials per kilo. The materials that are recovered for recycling are PET plastics and it sells for 2 dollar, metals as copper for 3 dollar, aluminium for 2 dollar and glass for 1 dollar (10.68 Mexican pesos is equivalent to 1 U.S dollar, March 2006)

### *The waste collection in the north of Mexico*

The region of the north covers the states of Baja California, Sonora, Chihuahua, Coahuila, Nuevo Leon and Tamaulipas. In this region, the waste collection system covers about 95 % and the total generation of waste was 3,874,217 tons/year (Graizbord, 2004). In general the cities of the north generate between 499 kg and 1.516 kg/day per capita. The composition of solid waste in this region is 54 % organic, 18 % inorganic and 28 % recyclable materials. Almost all the solid municipal waste generated in the north region goes to sanitary landfills while in other regions of the country; it is gathered in open landfills. According to Graizbord 2004, 64 % of the cities in the north leave the solid waste in sanitary landfills of which 49 % goes to municipal landfills, 15 % to

regional landfills, 28 % to controlled landfills and 8 % to open landfills that do not fulfil the environmental standards. About 36 % of the landfills are private and all fulfil the Mexican environmental standards.

Only some few cities in the north have payment for the collection system and after the NAFTA trade in cooperation with Comisión de Coperación Ecológica Fronteriza (COCEF), many cities have got economic support to improve the collection system and the landfills infrastructure. According to COCEF, 42 % of the population in the north does not have an adequate waste management. Since the north region is the one generating the most solid waste in the country, a project is iniciated to recover energy from the waste. This project will be completed in 2012 and it will be carried out only in 6 cities. Three cities in the north will have access to this landfill.

## *2.3 Recycling and Reutilization*

Recycling should be considered as a part of the waste management strategy. This means management that can give sustainable environmental improvement in order to diminish greenhouse gases, reduce the waste to landfills and provide proper use of the resources. In the recycling system a sequence of problems around the different phases: classification, collecting, transport, recycling and business emerge. One of the major problems related to recycling in México is to find a market for these recycled materials. The ineffective selling of materials can be traduced in economical income to the small markets. Commercialization of recycled materials requires cooperation of the industry to facilitate the use of these materials in new products.

There are two types of economic sectors in the recycling system: formal and informal (Medina and Jiménez, 2001).

The formal sector is the one complying with the laws. In this case the product, commerce or service must fullfil the standards.

In the informal sector, laws and standards are rarely followed.

The recycling industry in México consists of a large variety of busineses. These can be from one person to international industries and they are divided in five types (Chárraga and Durazo, 1999).

**Collectors**: Their function is to identify the materials, the transport of these materials from the source until collectors sell them. Among others we can find scavengers, who are men collecting iron and plastic in landfills.

**Stock Centra**: These centra receive recycled material that is sold directly to the industry.

**Independent Stock Centra**: These centra usually buy the material, and later sell them to the manufacturing industry. They handle the transport of material and charge free for this activity.

**Recycling plants**: These plants subject recycled materials to a cleaning process in order to use material for new products.

**Final users**: The industry that process huge quantities of recycled material to be used in their own products.

According to the National Recycling Institute, there are about 17,000 formal as well as informal recycle businesses in the country. It is estimated that the informal sector generates significant economic resources and about 2,000 jobs. However, there is a lack of recycling industries in the formal sector. A few companies exist in some states that have high industrial development.

The recycling industry is built on small industries that buy the materials to the informal sector by trading without invoice. Another part of the informal sector is the commerce without office, which takes over 10,000 small businesses (Urquidi, 2002).

In Mexico, the material recycling system has just started in comparison with countries like Sweden, Germany or USA. The separation of waste does not occur at source. Instead it is at first in the collector trailer, secondly in the selection plants of materials, and thirdly in landfills by the scavengers. As a note, only the selection plants of materials work in the formal sector, but only a few cities have these plants.

The quantity of recuperated materials in the landfills is minimal, only a small percentage of the materials go to recycling because the materials that arrive to landfills are already mixed with other garbage that makes it difficult to separate them. In the informal sector, there are also differences between the garbage collectors who do the work of separating the waste. These are garbage collectors, pre-scavengers and scavengers. The garbage collector is the one cleaning streets and removing the garbage from the streets. Later the material is sold to intermediaries. In Cuernavaca the garbage collector usually collects cardboard and metal since these materials are more often present in the waste of the city. They sell the materials for between 0.5 and 2 U.S. dollar.

During the process of municipal collection, pre-scavengers separate materials, such as cardboard, glass, paper and metal in the collector trailer. They also sell the materials to an intermediary, but pre-scavengers have the possibility to recover more materials as they receive the garbage directly from the houses.

Scavengers provide the final separation of waste and recover materials to recycling. This work helps to avoid that waste fills up the landfills but also allow

materials to return to the industry to make new products. The scavengers work under unhealthy conditions and they sell the recycled materials for a very low price. Many of them have had accidents with hospital waste, for example stabs from syringes or cuts from glass. According to an interview with a scavenger from Tetlama, they usually do not have social security and only go to a doctor if they hurt themselves with a syringe. Children, old people, ex-convicts and families are those who work in the landfills. The materials that are recycled in Cuernavaca's landfill are: aluminium, copper, cardboard, glass and plastics.

PET is a plastic with the quality of recycling owing to the resistance of the material. This kind is the most recoverable plastic in Mexico and in the world. In Mexico, the consumption of PET has increased during the last decade. The consumption of PET packaging was 105,931 tons/year in 1997 and it increased to 297,191 tons/year in 2001 (Cristian and Ize, 2003).

The capacity of the industry to produce synthetic resin reached approximately 2.5 million tons/year in which 77 % correspond to thermoplastic resin and 23 % to thermostable resin (Urquidi, 2002). All products made of thermoplastics are potentially recyclables, such as PET. Nowadays, many industries participate in the work to preserve the environment, so they have a centre for receiving PET bottles with the intention of recycling the material. The cost of the virgin material is lower than the recycled one (Cristian and Ize, 2003). Even so, PET is useful to make cloths, pillows and many more thermo products.

## *2.4 Final disposal*

Sanitary landfills have been and will be the final disposal for waste in Mexico, as long as they comply with environmental laws and the construction and operation is safe. The construction and development of landfills has increased considerably the last years but, even so, the most sophisticated landfill in Mexico has a low cost for its waste management. In some regions, the idea of producing energy from landfills through anaerobic degradation has been considered, but the cost for constructing this kind of infrastructure is so high that Mexico can't afford it.

In June 2004, the Official Mexican Standard, NOM-083 SEMARNAT-2003 came in vigour, and it specified how a landfill should be designed and constructed.

New constructions of landfills must fulfill the regulations which include separate treatment of leach water, gas collection pipes to regain biogas and recover energy.

The land must be prepared with separate access ways for transportation and cellblocks. The base of the landfill requires pipes to canalize leach water. When

the cellblocks close the garbage reception and reach the optimal size they are covered with mud compacted with a tractor.

A process that can be employed in landfills when their useful life is over is compact treatment. The purpose of this treatment is the reduction of the waste volume through and at the same time the control of the landfill.

In 2001, the country had 77 sanitary landfills that managed about 19 million tons of solid waste. According to a study, 64 % of the cities in Mexico deposit their solid waste in sanitary landfills. The most common landfills in Mexico are sanitary and open sky landfills (Guzmán and López, 2004).

According to the Official Mexican Standard NOM-083 SEMARNAT-2003 for construction and management of landfills in Mexico, there are four kinds of landfills. Three of them are described below.

**Sanitary landfill:** It is a construction that has methods and engineers for municipal waste final disposal. This is a controlled construction in which all the process is belived to prevent negative effect on the environment. The infrastructure includes landfill gas systems, operation and maintenance and leach water separate treatment system. Only 49 % of the collected solid waste in the country goes to these 77 sanitary landfills.

**Open sky landfills**: Is an inadequate place for final disposal of the waste. This place fullfills some of the specifications that a sanitary landfill must has, but does not have an impermeable construction. Almost 43 % of all solid waste collected in the country goes to Controlled landfills or open sky landfills. Many municipalities in Mexico have open sky landfills and they can cause health problems to the population and contamination to groundwater, among others things.

**Uncontrolled landfills:** Inadequate places for final disposal of the solid waste. This place does not meet any kind of construction specification, so the negative effect on the environment is huge. It is due to the leakage to groundwater, air pollution with methane gas. About 8 % of the collected solid waste goes to these uncontrolled places.

Leach water is formed when it mixes with waste in open sky landfills. This water contains huge quantities of contaminant elements, such as organic nitrogen, ammonia, soluble hydrocarbons, and heavy metal, such as Cadmium, Nickel, Zinc and Lead; consequently it can cause groundwater contamination. There are four ways in which leach water is formed in landfills: Rain water, direct waste contact with groundwater, liquid leakage from waste and external water that often moves horizontally in the base of the landfills (Guzmán and López, 2004).

It is common to find landfills where employees do not have the technical skill to solve the problems. Low salaries do not make this better, so management in landfills has become ineffective. The view of this is different in municipalities with better economic resources, where the employees have adequate technical competence and therefore competitive salaries.

Usually, it is the municipality that has the responsibility for the function of landfills, but after years of bad administration, some of them have been conceded to private companies. Currently 24 important cities have chosen to privatize some parts of the waste management.

The decree that establishes the rules of final disposal has as a goal to reduce the volume of organic waste that goes to landfills with up to 35 % compared to national levels registered in 1995.

## *2.5 Energy from waste*

Mexico has just begun the production of energy from the waste and it is due to the high cost of infrastructure that the country has not made it before. There is only one plant in all the country were landfill gas is used to produce energy. The aim of this plant is to reduce the methane emissions to the atmosphere that contributes to the greenhouse effect.

This plant is located in Salinas Victoria, in the state of Nuevo Leon. Salinas Victoria is an intermunicipal landfill where seven municipalities have jointly cooperated with the economic support of the government of Nuevo Leon and the World Bank. Since Salinas Victoria's opening in 2003, it has produced 7 MW upon which provides energy to the seven municipalities. Although the plant is working to 89 % of its capacity, Salinas Victoria needs to build another plant that can provide 6 MW more. The energy that will be produced from the new plant is used to provide energy for the subway transport, making the subway in Nuevo Leon the first one in the world that works by biogas.

## *2.6 Environmental education in Mexico*

Chapter 36 of Agenda 21 emphasized the role of education as a fundamental part of sustainable development for each country. In 1993, United Nations created an environmental education plan as a starting point for countries own education plans. In Mexico, the National Ecology Institute was in charge, together with UNESCO, the organization which introduced the plan (Maldonado and Garcia, 2005). According to this plan, education is the key to understanding the environment and the social cultural reality where knowledge can serve as a

base to find solutions for environmental problems (Maldonado and Garcia, 2005).

What Mexico wants, is to introduce as part of the national education program, the environmental education as a transversal topic. Transversal integration in subjects has gradually advanced due to the urgency and environmental problems that Mexico is going through (Maldonado and Garcia, 2005).

In Mexico, the Secretariat of Public Education (SEP), has the responsibility of the entire national education plan. SEP has begun to update the contents of the national education program, in which sustainable development has become a part. Other governmental organisations, such as SEMARNAT and CECADESU have collaborated to structure regional environmental education plans, in order to as have a better view of the needs that each region has, in what is refered to environmental issues. To reach this goal, CECADESU has used guidelines with development plans emphasizing environment elements where goals, objectives and plans are included. The purpose of these plans is to construct a link between government, community and organisation that can lead to a change in the attitude towards the environment.

In general, each region has begun different actions to structure environmental education strategies where universities and non governmental organisations are involved in order to build a platform to continue the construction of public politics.

In 2003, projects of environmental education started in many schools in the country. One of these projects is Crossed National by a Clean Mexico, where schools are challenged to handle their solid waste adequately. The three R: reduction, recycling and reutilization has been the key for the waste sorting program in schools. To carry out this project, strategies of communication, teachers training and education were developed. Parent's participation in the program is imperative. The purpose of this program is that all schools in Mexico create an adequate waste management throughout, giving values in the change of attitudes and consciousness of the students. SEMARNAT, with the assistance of other organisations such as CECADESU and/or CONANP are involved in the training and environmental education in schools and communities (Chárraga and Pardo, 2004).

The Decennium for the Education was initiated. The purpose is that sustainable development is integrated in the countries educative politics. It means that Mexico, as well as other countries has ten years to make a change and integrate the sustainable development to confront the environmental problems (Maldonado and Garcia, 2005).

# 3 WASTE MANAGEMENT IN SWEDEN

## *3.1 Laws and environmental regulations*

Waste management is one of the 15 Swedish environmental goals that were implemented in 1999 as an environmental policy for improving the sustainable development in the country (Naturvårdsverket, 2004).

In Sweden, waste management politics and laws has developed during the last thirty years. The waste market has also changed and is now managed thought standards, laws and rules that determinate who, when and where the responsibilities will lay.

During the 70's waste management was already an important part of the politic agenda in Sweden. In 1969, the Environmental Protection Law came in force, which implies and demands changes in landfill operations. A lot of landfills were closed after the implementation of this law. Many municipalities were forced to find new treatments and methods for the waste problem.

The oil crisis in the 70's made Sweden start to look for renewable energy that could replace oil usage. During this period, the construction of incinerations plants grew, in where energy could be produced to supply community infrastructure. A new and more complicated waste management were introduced in many municipalities. The government contributed with economic resouses for the construction of more incineration plants.

In July 1972, The Municipal Waste Management Law (1970:892) came into force (Naturvårdsverket, 2004). This law stated the municipality's right to take care of their household waste. This new law only reinforced the old way of work in the municipalities, because many of them had already local waste management systems. The Waste Management Law (1979:596) introduced in 1979 emphasized the municipalities right to manage municipal waste, i.e collection, transport and recycling (Naturvårdsverket, 2004).

The development that started during the 70's was refined during the 80's. The biggest change was introduced in 1986 with the mandatory municipal collection of hazardous waste. During those years, the collaboration between recycling bussines and producers was reforced in order to increase paper, battery and glass recycling.

A Waste Collection Regulation in 1990 (1990:984) extended the municipal responsibility for collection of waste. In the same year, a requirement was introduced demanding that the municipalities must have a plan in describing the management of their waste (Naturvårdsverket, 2004). In the same year, the increasing demand of household sorting, recycling and service introduced recycling centra as an important part of the waste management. In the early

90's waste politics was more focused in the origin of the garbage and also in reducing the amount of the garbage. Changes were done for health and environmental reasons, so further demands were introduced in order to reduce the material usage through recycling and reusing materials.

The 1st of January 1999, The Environmental Law (Miljöbalken 1998:808) came in force and many of earlier environmental laws were invalidated. This law constitutes the basis of the waste management system in Sweden. The new Environmental Law stipulates how the waste management should be carried out, for example, collection, transport and final disposal.

The definition of dangerous waste changed in 2002 and after a change in The Environmental Law in 2004, elucidates the producers responsibility for their waste. In 2002, a ban on deposition of combustible waste in to landfills was introduced and in 2005, it was also made illegal to deposit organic waste in landfills.

## *3.2 Waste collection systems in Sweden*

Household waste is classified in the following categories: (Löfgren, 2003)

*1. Organic* is all organic waste for example: all kind of food scraps, vegetables and fruit.

2. *Inorganic waste,* the waste that can not be composted for example: plastic bags, diapers, stub and glass.

3. *Recycling and reuse waste* including cardboard packaging, paper, coloured and clear glass, metal, plastics and clothes.

4. *Hazardous waste,* consisting of everything that contains mercury or other heavy metals, paints, batteries, insecticides and cleaning agents.

In Sweden, a single-family house refers to a private house, semi-detached housing, terrace housing and buildings with a maximum of four apartments. A Block of flats refers to buildings with more than five apartments. The population in Sweden is around 9 million people; 60 % of the people live in blocks of flats, while 40 % live in single-family housing. While waste collection is different depending on the type of the housing, the sorting of waste applies for both types of housing (Löfgren, 2003).

The total amount of waste produced in households is 2.7 million tons/year. Each person generates between 322 kg and 780 kg each year. The type of waste varies depending on the social conditions, housing structure and geographic location.

In Sweden, the municipality is responsible for the technical solutions for waste management and decides if the town should compost, use an incineration plants or biologic treatment, in the form of a biogas plant. Many municipalities have started campaigns to promote composting in individual households. In 1999, Sweden had 31 installations for biological waste treatment, 24 of which are for composting; the seven other installations are used to produce biogas (Löfgren, 2003).

Most of the total produced waste can be re-used (See Figure 3). The largest section, 44 %, is organic household waste and it can be used for compost or biogas. The next largest section is 43 % and it consists of paper and cardboard, which can be recycled. Only 12 % are combustible inorganic. Some of this waste is incinerated to produce energy and the other part is sent to landfills. One percent of household waste is considered hazardous and cannot mix with the rest of the waste.

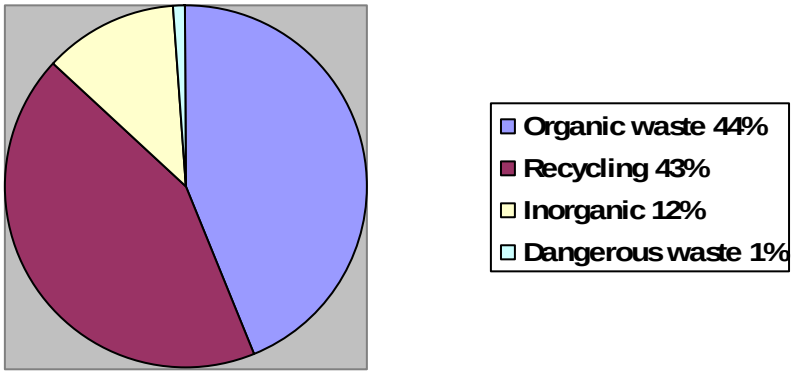


***Figure 3. Distribution of four waste fractions. Source: RVF 2004***

### Technical systems for inorganic waste management

There are many different waste collection systems in Sweden. Examples of these systems are Optical Sorting, Sorting by Sacks, the Combi-System and Waste Suction; they are designed to satisfy the present and the future environmental laws. The different systems operate in many municipalities and most of them are used for both single-family or block housing (Löfgren, 2003).

### Optical sorting

Optical Sorting was developed in Borås, Sweden in 1990 by Larsson and Wahlquist (Optibag, 2005). The first plant was built in Borås in 1991, its development later became international and the idea spread too many European countries. Optical sorting is a system for handling household waste sorted at source. The system works using different bags. The plastic bags have

different colours: green for organic, red for combustibles and white or black for other waste. The bags are transported along a conveyor belt, which has a colour sensor that reads the colours of the bags. The bags that do not have the right colour are transported to a landfill, inorganic waste bags (red) are transported to an incineration plant to produce energy and the organic waste bags (green) are transported to a biogas plant (Optibag, 2005).

The new Optical sorting plants have the capacity to sort for more colours. There is the possibility to sort paper, plastic, metal and glass in the recycling stations.

In order for this system to function, people must understand the importance of sorting their waste. In many of the municipalities that have the Optical sorting system, inhabitants must buy their own differently coloured plastic bags so that they are more conscious of separating their waste.

The system is very flexible because it fits well with most waste management systems. An advantage of the Optical sorting system is that all the waste can be collected in the same container. However, it only works if the waste has been correctly placed in the appropriately coloured plastic bags.

By dividing the waste into three parts, the Optical sorting system helps to diminish the waste's impact on the environment.

**Combi System™**

The Combi System was developed in the municipalities of Bates/Korsnäs in collaboration along with support from various other partners. The Combi System is designed to function well not only for the separation of waste but also for waste collection workers. The Combi System comes with an internal structure, which is covered by a plastic top. Air ventilates through the structure, making it ideal for an open-air compost system. The container is adjustable, depending on the size of the person. The system works best in a single-family house because of its size. The Combi System is relatively new and, so, it has not yet spread too many other municipalities. Unfortunately, the cost of the Combi System is large in comparison with other systems because its production is only on a small-scale (Löfgren, 2003).

**Organic waste**

Waste, which can be composted, accounts for 40 % of the household waste in Sweden, as already mentioned. Thus, organic waste separation has been a pillar in the waste collection system. A new national goal has recently been introduced; proposing that by 2010, 35 % of all organic household waste will be biological treated (Rvf, 2005). In 2003, 9.6 % of the organic household waste was treated biologically, resulting in the composting of 407,785 tons of organic material.

After the collection of organic waste, there are two possible treatments. One is composting, which occurs through an aerobic process making it useful for open system collection. The other process occurs anaerobically and here, the collection should be done in a closed system to maintain the moisture and to prevent air from entering. In the past, organic waste has been difficult to manage because of its high moisture content. Additionally, organic waste that was kept in closed containers ran the risk of growing mould or other micro organisms. Today, to prevent these problems, organic waste Sweden is stored using both open-air and closed-air composting systems.

The open system allows for aerobic decomposition, by storing the waste in paper bags or ventilated containers. Because the air mixes with the organic material, it prevents anaerobic decomposition and the bad odour that comes as a consequence. The closed system of composting uses plastic bags where no air can enter. The anaerobic decomposition begins when the waste is placed in plastic bags; because there is no oxygen, this process is producing gas. This system is common in many of the municipalities that have plants to produce biogas.

All organic waste is collected in plastic or paper bags, which can then be transported to any of the treatment plants. Various municipalities also have a plan to collect garden waste, which is considered a clean waste product. It is collected in separate containers during the summer season and is then brought to the appropriate treatment plant. The treatment plants for organic waste produce soil, which can be used as fertilizer, garden soil, or fill, or biogas.

## *3.3 Recycling and reutilization*

**The industry's responsibility**

Under the industry's responsibility law that came in force in 1994, it is responsibility of the industry to take care of the materials and residues that they produce. It means that the producers create a system where the people can leave their recyclable waste products.

Recyclable waste that is covered by the industry's responsibility is: newspapers, magazines, metals, plastics and glass. There are also containers for batteries and textiles. The industries created a corporation, where the collection of recycled materials is organized**.**

The solution that industries came up with for the collection of recycling waste was recycling stations. Recycling stations are the places where inhabitants can throw their recyclables. The stations are unattended places with containers for

each waste fraction. Recycling stations must be situated in accessible places so that everybody can use them.

The appearance of containers is different in every municipality and the containers are also designed considerating the work environment. Each container has a symbol which says what kind of waste can be throw in it. In many municipalities, you can find information in different languages. New containers have been designed with a signal that is sent to the collectors when the container is full. Collectors have 24 hours to clear the stations.

All paper that is recycled can be reused in the industry to make for example new toilet-paper or newspaper. From recycled cardboard, you can manufacture new cardboard or plaster boards.

Plastics are sorted by different industries and can be melted and become new plastic products. Other kind of plastic is used for example as noise planking or compost containers.

Metals are sorted by different industries before it is melted and becomes raw material to manufacture new metal products.

Glass is reused by the glass industry and later becomes new bottles small percentage goes to manufacturing isolation material.

Batteries be sorted after its type and some of them become new batteries and other deposits in landfills.

Clothes sell for the benefit of international relief work.

**Big waste**

Waste that cannot be thrown in containers because its weight and size, for example old furniture, bicycles or buggies are call "big waste". The municipality has the responsibility to also collect this kind of waste. For single family houses it is common that they transport their own big waste to central recycling stations. Also, families can choose that it is collected at home.

In apartment blocks, the storage is not big enough to contain all the waste. The solution to this problem was to arrange skips so they are available for big waste disposal. Big waste can be transported to central recycling stations where it can be sorted by its contents.

## *3.4 Final disposal*

Landfill usage has developed slowly in Sweden and has changed because of the introduction of other more environmentally sound treatments.

During the 1980's, various improvements were incorporated into landfill management: (Rylander, 1991)

- Final disposal for incinerated waste
- Use of cells and cell blocks in landfill management
- Compaction and coverage methods
- Separate treatment for leach water
- Final disposal for biodegradable material
- Gas collection and usage

New laws created in 1994 do not permit untreated waste to be disposed in landfills and also, guarantee that the gas produced by the landfills must be collected. Landfills that receive little waste must be closed. Additionally, the number of landfills that will be closed will increase in the future. All this comes along with the new law of composting, recycling and reuse. As a result of these laws, the deposited waste in landfills has decreased from 3.8 million tons in 2002 to 2.9 million tons in 2003 (See Table 2).

***Table 2. Total amount of deposited municipal waste in million tons/year. Source: RVF 2003***

| Year | Million tons |
|---|---|
| 1994 | 6,080 tons |
| 1995 | 5,340 tons |
| 1996 | 5,050 tons |
| 1997 | 4,750 tons |
| 1998 | 4,800 tons |
| 1999 | 4,900 tons |
| 2000 | 4,450 tons |
| 2001 | 4,240 tons |
| 2002 | 3,770 tons |
| 2003 | 2,940 tons |

The largest landfills in Sweden receive about 2/3 of the country's waste while the small ones receive about 20 % of waste. The gas that is produced in landfills is mostly methane, which is a greenhouse gas. If the gases from landfills are not collected, they can enter the atmosphere and contribute to the greenhouse effect. In Sweden, these gases are used to produce electricity and energy during the winter. During 2003, there were 75 landfills that produced gas, totalling in 443 GWh of electricity. 414 GWh were used as heating energy, while 26 GWh were used as electricity and 3 GWh as vehicle fuel.

***Table 3. Plants that produce biogas in Sweden 2003. Source: RVF 2004***

| **Biogas utilization** | **Nr. of plants that produce gas in the entire country** | **Produced energy (GWh)** |
|---|---|---|
| Heating energy | 59 | 414 |
| Production of electricity | 9 | 26 |
| Vehicle fuel | 2 | 3 |
| total | 70 | 443 |

## *3.5 Energy from waste*

**Incineration**

In 1973, during the first oil crisis, Sweden began to look for alternative methods of producing energy that did not negatively affect the environment. While non-renewable energy resources will eventually run-out, renewable resources, like waste, will always exist. As such, incineration is a good alternative energy source.

Sweden has one of the world's most innovative incineration plants; it is run by RENOVA, a Swedish waste handling company, based in Gothenburg. RENOVA has permission to incinerate 460,000 tons waste each year. This incineration plant produces electricity that meets the annual needs of 60,000 flats. Additionally, it provides heating and hot water for about 120,000 flats. The renewable energy from incineration plants is equal to that of 120,000 tons oil or 120 cubic meters of nature gas. Daily, about 300 vehicles come to RENOVA and the waste is sorted before it is burned.

Incineration reduces the volume of waste, as well as destroying infectious and toxic material. In 2003, 1,893,090 tons of waste was incinerated, corresponding to 45 % of all domestic waste. Sweden also imports wastes to incinerate, corresponding to 5 % of the total amount. Additional energy is produced through burning plastics and fuel. In 2003, there were 28 incineration plants in Sweden.

Sweden is a leader in producing energy from waste in comparison to other countries in Europe. During 2003, it produced 9.3 TWh of energy and distributed in 8.6 TWh in heating and 0.7 TWh in electricity.

Heating from incineration of waste meets about 15 % of the total municipal heating needs. In some municipalities, incineration covers half of the heating needs.

New laws about contamination of the air and water have came into affect, causing incineration plants to be more careful in what types of materials they burn. The law is already in effect for new incineration plants and will start on December 28, 2005 for old incineration plants.

**Biogas Production**

In recent years, the number of biogas plants has increased throughout Sweden. Biogas is produced through a digestion process, resulting in 2/3 methane gas and 1/3 carbon dioxide gas. The anaerobe process causes the degradation of organic material, like food waste, manure and sludge. Biogas has many different uses and is produced in more than 200 plants in Sweden, most importantly, in sewage treatment plants (Javis, 2004).

Sweden is one of the few countries that use biogas as a vehicle fuel, i.e. cars, buses and trailers. During 2003, the Swedish production of biogas, compost and rotting process increased in comparison to 2002.

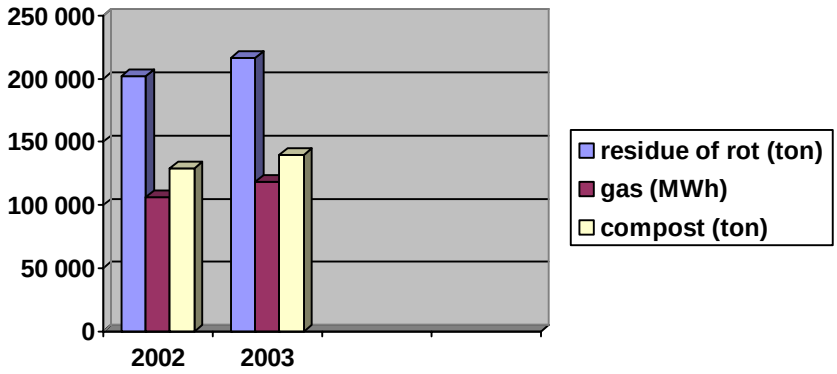


***Figure 4. Biogas and composting products in Sweden. Source: RVF 2004***

## *3.6 Environmental education in Sweden*

The Swedish Environmental Protection Agency has received the commission to teach the public about the proposals found in Agenda 21, the Rio Declaration on Environment and Development. This agency works to increase the community's environmental knowledge, promoting ecological, sustainable development. The Swedish Environmental Protection Agency and the Swedish Association of Waste Management (RVF) are two of the governmental organisations that, among others, do research about waste issues. The organisation that works primarily with waste topics and energy is RVF. In RVF's homepage, there is information and statistics as well as discussions on how

waste management issues have been dealt with in recent years. Research results come out each month in the form of reports, which are available in all the libraries in the country or on the RVF homepages.

In 1990, the Swedish government decided that all municipalities must have a plan for the waste management. The municipality's waste management plan must contain information, figures and data about waste in the community, as well as measures that the municipality has taken to reduce waste quantity and risks. As a part of this plan, education about waste management must be provided to the public.

The goal of the plan was to promote consciousness about the importance of sorting waste at home and at the same time to reduce harmful waste. Before introducing the new system of waste separation, the public was given a lot of information about the new program. This included various local campaigns about the importance of composting and battery collection. The Swedish Environmental Protection Agency, the Swedish Association of Waste Management, the municipalities, and industries supported these campaigns, which explained the goals of waste separation in various media, including brochures. Overall, a total of 1 million U.S dollar was spent.

Each municipality in Sweden has a homepage about waste management, explaining how waste should be treated and also what kind of measures the municipality has introduced. The Internet is a powerful tool to spread information to the society about how waste should be managed. Additionally, to reach all the levels of society, different participants, especially personnel in schools and universities, have been asked to help with environmental work. The environmental education program considers many environmental issues and one of them is information about waste sorting. For example, many universities give conferences and courses related to this subject.

# 4 COMPARATIVE ANALYSIS

## *4.1 Economic conditions*

For México and for the rest of the countries in Latinamerica, the 80's was considered a "loss" in terms of economic development (CONAPO, 2004). From 1940 to 1981, Mexico has had a stable economic growth but in 1982, the country entered economic crisis. This crisis was also called the "debt crisis" and it originated from the international oil crisis that raised the interests on Mexico's international debt (CONAPO, 2004).

During the 80's, the economic crisis led to unemployment, fall in salaries and an increase of the informal economy, for example the markets between scavengers and entrepreneurs. Evidently, those crises affected the development of the country and the effects of poverty are visible until now.

Despite the stabilisation of Mexico's economy during the 90's, a huge social and regional inequality in the country still continues. This inequality depends on the economy of each region but also the resources that local governments give to environmental projects, for example waste management.

There are also huge social and demographic differences between Mexico and other countries. For example Mexico's GNP per capita is almost a quarter of United States GNP, and a third of the average GNP of countries from the Organisation for Economic Co-operation and Development (OECD) (CONAPO, 2004). This disparity can be seen in the differences of the salaries from the manufacturing industry between United States and Mexico. The US has 6 times higher average salaries than Mexico does (CONAPO, 2004).

Mexico still has a big gap to developed countries in what concerns research and development budget, productivity, education, health and environmental care. According to Anacleto Pedraza from the PRD party, the government doesn't spend on environmental projects for example improvement in landfills or waste water treatment plants. He says that in Mexico the budget still goes to priority projects as infrastructure, health and work so the care of the environment remains in second place.

But still a lot of effort has been done to reach the international goals which Mexico has signed in to improve the environment. In fact, environmental politics in Mexico strives to promote sustainable development and educate the population in order to understand the importance of managing natural resurces without damaging the ecosystems. Even that demographic growth has decreased in Mexico the last decades, the population still demands huge quantities of natural resources to fulfil basic necessities.

After all the Mexican efforts, the country will be continuing facing environmental problems as land use, water and air pollution.

The main problem of soil contamination has been waste in landfills. This is because there isn't an effective control of the management in landfills and the lack of proper technology (CONAPO, 2004). So, improvements in those specific issues and the use of proper technologies in Mexico will happen when the environment takes an important place in Mexico's politic agenda.

In Sweden, the economy growth was stable between 1945 and 1975. A technology gap was a result of The Second World War between USA and rest of the world.

The Swedish productivity, as well as Japan's, started to grown fast with the help of technology imports from USA. Other factors in the fast economy growth in Sweden were the expansion of the industry.

During the 60's, Sweden increased its international market, which raised the GNP for the country and during the 70's Sweden became one of the richest countries in the world (Regeringskansliet, 2006).

## *4.2 Work environment*

The work environment within the Swedish waste management has been developed through the years. It is because waste treatment work places must fulfil a strict law and also because extensive reseach has been done through the Swedish Environmental Institute (IVL 2002). The waste treatment plants usually have regular inspections from the Work Environmental Agency in where the agency demands improvements of places that don't fulfil good work conditions. Despite all the technology that Sweden has to carry out collection, treatment and sorting of waste, there is still a lot of manual fine sorting in recycling industries. According to IVL's research, manual fine sorting work can cause sickness because bad hygiene, repetitive work or bad body postures.

The common problems that workers in Sweden have to face during manual fine sorting, collection and transport are health risks, ergonomic risks, physical risks and other risks, presented in Table 4. The dust is one biological risk that comes from recycled paper and from other paper packages in which the dust sometimes exceeds the average limit of exposure at work. Microorganisms can easily grow in sticky or wet paper and there is a risk for workers for inalation of bakteria. This can also cause some odour problems in sorting plants. Lead poisoning is still chemical risks for workers that recycle lead batteries in Sweden. It was a usual injury before for workers in Sweden but nowadays are heavy metal spreading under control.

Traditional ergonomic risks that occurs during the process of waste collection is lifting of containers. In Sweden the risk has decreased because the vehicles for collection and transport of wastes are designed to diminish the ergonomic risks. Physical risks, such as high noise levels in sorting plants can cause impared hearing and repetitive work leads to back injuries. To decrease health risks many waste treatment plants reduced time exposure for manual sorting work.

Other risk during the manual sorting in waste sorting plants are cutting or pricking from broken recycled glass.

***Table 4. Occupational risks of Swedish waste handling. Source: IVL 2002***

| **Waste** | **Chemical/bio-logical risks** | **Ergonomic Risks** | **Physical risks** | **Other risks** |
|---|---|---|---|---|
| Recycled waste as paper, packaging of glass, metals and plastics,<br>Batteries | Dust, microorganisms and heavy metal poisoning | Repetitive and prejudice movements with lifting of containers | Illumination, noise and<br>Climate | Cutting and<br>pricking |

In the Mexican waste management system work environment has not been considered an important factor. This is because the current system is focusing more on impacts in the external environmental than in the work environment. The work environment during all process of waste management is very bad for workers in Mexico. Also, it is important to point out the even worse conditions for workers from the informal sector or scavengers in landfills. Scavengers come from the lowest social levels and have difficulties to find a job. It is because of low educational level or because of difficulties to find job as ex-convicts. All workers in the waste management process have a low education level and it's difficult for them to know about the risk factor and health effects that a bad work environment produces. Risk factors for workers in landfills, collection, transport and sorting plants are presented in Table 5.

Because the lack of technology in landfills or in sorting plants, work injuries are more severe. Life expectancy for landfills scavengers is 39 years and many of their children die before their first year (Sundgren, 2003). A lot of families live in landfills and they have small communites with houses that they build themselves. Children only attend primary school in the nearest town, because they help theirs families with recycling collection (Interview with scavengers in Tetlama landfill, 2005).

***Table 5. Work Environmental risk problems from waste handling in Mexico***

| **Waste** | **Chemical/bio-logical health risks** | **Ergonomic Risks** | **Physical risks** | **Other risks** |
|---|---|---|---|---|
| Inorganic, organic, recycled and hospital waste | Microorganisms, bakteria, viruses, dust, poisoning of heavy metals | Repetitive and prejudice movments with lifting of containers | Climate and noise | Cutting, prick and insect bite |

The biological risk factors are enormous in consideration that hospital waste contains everything from syringes to liquid subtances. Since scavengers don't use adequate clothes or masks when sorting waste, a lot of substances can easily come in contact with the skin or breathing lungs. Particles in suspention like dust deposits in the respiratory system (Alvarez, 2002).

Chemical risk of heavy metals as mercury and lead can often occurs during collection, transport and in landfills (Alvarez, 2002).

Ergonomic conditions during the collection are bad because the collector trucks aren't the adequate for this job. The repetitive movements from lifting bottles etc. can result in muscle, neck and shoulders injury.

One physical risk for scavengers is the climate because they work 12 hours in open sky landfills in 38°C sunny weather. For workers that transport waste, risks are, for example, the noise of the trucks and climate.

Other risks in landfills are cutting from glass and insects bites from scorpions.

## *4.3 Comparison of the laws*

"It is the employer who has the responsibility for good work environment. It applies for the technical equipment as well as the planning of the work". This is written in the Swedish Work Environmental Law 3 chapter 2, 2a, 2§ (Arbetsmiljöverket, 2002). The work environmental law was accepted in Sweden in 1977 and came in power in July 1978 (SFS 1977:1166). In this law, all the fundamental rules are described, but the details of the rules are described in the work environment regulation. Some examples of laws are given in Table 6. In this list, it can be seen that the starting point for environmental legislation is around 1970 for both countries. As time progresses, the time gap between comparable laws increases.

***Table 6. A selection of Mexican and Swedish environmental legislation***

| **Mexico** | **Sweden** |
|---|---|
| The Federal Law of Control and Prevention of Pollution (1971) | Law for the protection of the environment (1969) |
| The General Law of the Ecological Equilibrium and the Protection of the Environment (1988) | Regulation for the protection of the environment (1981) |
| The General Law for the prevention and Integration of the Solid Waste (2003) | Law and regulation of cleaning, collection and final disposal (1979) |
| Regulation for the management of hazardous waste (1993) | Regulation for hazardous waste (1985) |
| Regulation for the selection, design, construction, operation, monitoring and closing of final disposal (2003) | Regulation for batteries harmful to the Environment (1989) |
| | Law of waste management (1990) |

## *4.4 Comparison of the different methods, efficiency and efficacy*

The differences between the waste management systems in each country commence with the difference in generation of waste, population and kind of waste. Each system used in every country has been adapted to waste quantity. Mexico's population is ca 100 million people and if we count Mexico's generation of waste, it was about 29.2 million tons of waste in 2003. In comparison to Sweden that has a population of ca 9 million people the total amount is very low, with only 2.7 million tons/year. The content of the waste is also different in both countries. Mexico's generation of waste for each fraction is 53 % of organic matter followed by recyclable waste with 28 % and inorganic constitutes 19 % of all waste produced in the country. While organic waste is the largest fraction in Mexico, the fractions of waste are more equal in Sweden with 44 % organic matter, 43 % recyclable, 12 % inorganic and 1 % hazardous

waste. Mexico does not yet have data for hazardous waste, because is still mixed with the rest of the garbage (See Table 7).

***Table 7. Generation of waste for fraction in Mexico and Sweden***

| **Fraction of Waste** | **Mexico** | **Sweden** |
|---|---|---|
| Organic | 53 % | 44 % |
| Inorganic | 19 % | 12 % |
| Recyclable | 28 % | 43 % |
| Hazardous waste | - | 1 % |

After the oil crisis in the 70's, Sweden developed alternative energy generation, such as waste incineration. The incineration can thus cover some of the energy that is needed during the winter. Nowadays Sweden has 28 incineration plants that cover the entire country.

México has not been through a comparable oil crisis, because the country has its own oil, water power, geothermal power and coal electrical plants. So the necessity to build alternative energy plants is not the same. It was after the Rio Convention in 1992 that México realized the importance of renewable energy for the conservation of the environment. Under many years, incineration plants have been constructed in some cities in México, but high costs of maintenance and pollution problems after incineration has resulted in that the plants have been closed.

Concerning the percentage of waste that arrives to landfills, Mexico has the largest figure, 50 % of the waste is deposited (adequately), while in Sweden only 2 % of the generated waste is deposited. It is because sorting is more efficient in Sweden and, besides, there is a law that says that waste which is not separated or treated can not be deposited in landfills.

In the Mexican system there are no figures for compost treatment because this is not part of the system. Only a few municipalities have begun with compost treatment in México, so the percentage is very low in comparison with Sweden. The Swedish system has been working principally because the successful collaboration between the three levels of political power. The link between government-region-municipality makes the system work in the same direction with one common target. In Mexico the collaboration between the three levels of political powers has not been effective. Since the introduction of LGPGIR the government-state-municipality must collaborate together planning a functional waste system. Even though the law has been in force since 2003, the work

between these three powers has not begun up till now in the majority of the states.

The government in Sweden requires each municipality to make a plan for their own waste system. Each municipality makes a choice of what kind of technological system is wanted in each region. Everything depends on the regions economical activity. The functionality of the Swedish system, in comparison to the Mexican, is firstly the technological part and secondly that population's general knowledge of and compliance with the implemented system. The general information that is constantly given to the public about the importance of the waste system has been essential for people to collaborate with the program.

For a system to be successful, it must be work equal in all the municipalities and at all the social levels. Large gaps have been experienced running the system in México City, where the sorting of garbage has been implemented. There, the vehicles for separated waste only go through some neighbourhoods, making social differences obvious in the system. Other neighbourhoods are also sorting their garbage, but it is mixed in the vehicles and deposited in the landfills. This situation has alienated people, who do not feel part of the system and as consequence of this; people do not want to collaborate with the implemented waste system.

In Sweden, differences between social levels are not so visible and the information reaches all regions. The information given to the people is how the waste system works, current legislation and the importance of sorting the garbage at home. The environmental education in Sweden has been integrated since many years in the schools and information has been distributed through mass media, such as the radio and television. The environmental education is starting in the school system in México. For the rest of the population and in some remote regions, the information is not available.

## *5. Conclusions*

The implementation of the Mexican waste management system is still in progress and the goal is to introduce the system everywhere in the country before year 2012. The process of introduction will probably take more time than expected due to the lack of economical resources.

The Mexican efforts to preserve the environment have been growing during the last decade and people in Mexico have become more conscious about environmental problems. This has been an advantage in the process of developing the waste system.

The Mexican authorities show a tendency to blame the problem of cities getting dirty on the lack of education among the population. I think that the authorities have not reflected over the entire problem and what causes the problem. The environmental education must not only be introduced to the people, but also to the politicians. In most of the cases the politicians are not interested in investing in environmental programs.

As I observed during my visit in Mexico it is difficult to find a trash can in public places and when you find one, it is often broken, therefore it is not so strange that you find garbage in the streets.

The municipality should start charging for the waste collection service in order to improve the waste system in Mexico. Payments will give economic resources to the municipality, to invest in infrastructure for the treatment of waste. Another factor which should be included in the present system is the work environment, which is a key to the developing of an efficient work.

The Swedish system is well developed and while the problems are not huge, as in Mexico, it still needs improvements, such as better work environment. Sweden's system has been working well since it started and it can be used as a reference and model for waste systems in other countries.

## References

Alvarez Davila, Eliana (2002). *Manuell och Maskinell Sortering av Avfall-Nationella och Internationella erfarenheter av Teknik och Arbetsmiljö.* IVL rapport B1452. [Elektronisk] Stockholm:IVL p.7-9 Tillgänglig: <htpp://www.ivl.se/rapporter/pdf/B1452.pdf>

Berg Per OB & Mattsson Cecilia (2000). *Insamling av hushållsavfall: en kartläggning och analys av system för hantering av hushållsavfall och förpakning*. Stockholm: Naturvårdsverket

Chárraga Hernández, Ligia (2003). *Manual de Manejo Adecuado de Residuos Sólidos*. México, D.F: SEMARNAT / CECADESU

Chárraga Hernández, Ligia and Provencio Durazo, Enrique (1999). *Minimización y manejo ambiental de los residuos sólidos.* México, D.F: SEMARNAP/INE

Chárraga Hernandez, Ligia (2003). *Planes estatales: estrategias de educación ambiental*. Impulso Ambiental vol:nr 16 p. 26-30. México D.F: CECADESU

Chárraga Hernandez Ligia, Pardo Camarillo Guadalupe and Contreras Ortega Rebeca (2004). *Cruzada Nacional por un México Limpio: Escuela Limpia*. Impulso Ambiental vol:nr 21 p. 9 -13. México D.F: CECADESU

Cristán Frías Arturo, Ize Lema Irina and Gavilán García Arturo (2003). *La Situación de los envaces de plástico en México.* Gaceta Ecológica vol:nr 69. México D.F: INE SEMARNAT

CONAPO (2004). *Informe de Ejecución del Programa de Acción sobre la Población y el Desarrollo 1994-2003.* México informe 1era edicion

Garcia Castañeda David, Director of Public Cleanising at the Environmental Department of Cuernavaca. Interview Cuernavaca April 25th, 2005

Graizbord, Boris (2004). *Programa Estratégico de Desarrollo de Infraestructura Ambiental Sustentable en la Frontera Norte, Horizonte al 2012*. México D.F: El Colegio de México and SEMARNAT.

Guzmán Delgado Gerino and López Ortega Mauro (2004). *Los rellenos sanitarios*. Impulso Ambiental vol:nr 21 p. 14-17. México D.F: CECADESU

Jarvis, Åsa (2004). *Biogas, Förnybar Energi Från Organiskt Avfall.* [Elektronisk] Uppsala: Svenska Biogas Föreningen. Tillgänglig: <http://www.sbgf.org > [2005-03-13]

*Källsorteringshandboken* (1997). Göteborg: Renhållningsverket

Löfgren, Tommy (2003). *Återvinningshandboken 2003.* Vällingby : B & F Media AB

Maldonado Salazar Teresita del Niño Jesús and Gacía Calderón Serapio (2005). *Educacion para el desarrollo sustentable ¿otra moda? / Educacion y Medio Ambiente.* Impulso Ambiental vol: nr. 28, p. 10-16. México D.F: CECADESU

Martinez , Anabel El Colegio de México. Inteview México City April 26th, 2005

Medina Roos José Antonio and Jiménez Yanez Isabel (2001). *Guia para la Gestión Integral de los Residuos Sólidos Municipales*. México D.F: SEMARNAT

Micheli, Jordy (2002). *Política Ambiental en México y su dimensión Regional* [Electronic]. Región y Sociedad*,* vol XIV: nr 23. p.139-146.El Cole gio de Sonora <http://lanic.utexas.edu/project/etext/colson/23/23_5.pd> [2005-01-28]

Naturvårdsverket (2000). *Från ord till handling nationell kommunikationsstrategi för Agenda 21*. rapport 5059. Stockholm: Naturvårdsverket

Naturvårdsverket (2002). *Samla in, återvinn! Uppföljning av producentansvaret för 2001 men också mycket mer*. rapport 5237. Stockholm: Naturvårdsverket

Naturvårdverket (2004). *Marknaden för avfallshantering.* rapport 5408. Stockholm: Natruvårdsverket

Norma Oficial Mexicana NOM-083 SEMARNAT-2003. *Especificaciones de Protección Ambiental para la selección de sitio, diseño, construcción, operación, monitoreo, clausura y obras complementarias de un sitio de dispocision final de residuos sólidos urbanos y de manejo especial.* México D.F

OptiBag (2005). *Om Optibag*, *Historik*. *anläggningen, Optisk sortering.* [Elektronisk]. Mjölby: Optibag. Tillgänglig: <http://www.optibag.se/ > [2005-03-08]

Pedraza, Anacleto Partido Revolucionario Democrático PRD. Inteview Cuernavaca April 18th, 2005

Quadri de la Torre Gabriel, Wehenpohl Gûnter, Sanchez Gómez Jorge, Lopez Villalobos Alejandra, Nyssen Ocarasa Alejandro (2003). *La Basura en el Limbo*: *Desempeño de Gobiernos Locales y Participación Privada en el Manejo de Residuos Urbanos.* México D.F: Comision Mexicana de Infraestructura Ambiental

Renova (2005). *Om Renova, anläggningar, avfallskraftvärmeverk, komposteringsanläggning, fordon.* [Elektronisk]. Göteborg: Renova. Tillgänglig:

< http://www.renova.se> [2005-03-13].

RVF Svensk Renhållningsverksföreningen (2005). *Biologisk behandling*. [Elektronisk]. Rvf. Tillgänglig:<http://www..rvf.se/m4n?oid=333&_locale=1 >[2005-02-02]

*Förbränning med energi utvinning* [Elektronisk] Rvf.

Tillgänglig: < http://www.rvf.se/m4n?oid=334&_locale=1 >[2005-03-14]

*Deponering* [Elektronisk] Rvf. [Elektronisk] Rvf Tillgänglig:

< http://www.rvf.se/m4n?oid=334&_locale=1 >[2005-03-08]

Rvf utveckling (2004). *Avfallsförbränning: utbyggnadsplaner behov och brist.* rapport 2004:02. Malmö: RVF

Rvf utveckling (2003). *Studie av fastighetsnära insamlingssystem för hushållens farliga avfall i Sverige*. rapport 2003:07. Malmö: RVF

Rvf utveckling (1999). *Goda exempel på kommunal avfallsinformation*. rapport 1 999:01. Malmö: RVF

Rylander Håkan (1991). *Avfallshantering i Förändring*. Stockholm: Allm. förl

Silva Valdez Alfredo (2005). Programa Operativo Anual 2005. [Electronic] Cuernavaca: *Secretaria de Servicios Públicos y Medio Ambiente*. [accessible]: <www.cuernavaca.gob.mx/Libreria/ pdf/transparencia/dependencias/1/poa.pdf> [2005 06 08]

Ulf Ulfvarson, Mats Ericson and Per Odenrick, Oliver Renborg (1997). *Arbete-Människa-Teknik*. Stockholm. Prevent

Urquidi, Victor L. (2002). *El problema de los desechos industriales en México*. Industria y Ambiente, vol 52: nr 3, p. 216-220. México D.F