# Chapter 3 Diagnosis of municipal solid waste (MSW), in the State of Mexico

# Capítulo 3 Diagnóstico de los residuos sólidos urbanos (RSU), en el Estado de México

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**Abstract**

The purpose of this paper is to evaluate the diagnosis of urban solid waste (USW) in the State of Mexico, through the framework of sustainability. Urban areas represent a focus of attention for local administrations since they represent spaces of economic importance in the Gross Domestic Product. At the same time, these areas favor the concentration of population and air, water and soil pollution in these areas. The analysis included documentary review and diagnosis of urban solid waste (USW) in the State of Mexico, for which it is necessary to investigate different aspects of utmost importance, as well as some background information that involves not only the state, since in order to compare it is necessary to know the management of USW in Mexico at a national level first and then focus on the State of Mexico. As we know, MSW has increased over time due to the demographic and industrial growth of the country, the change in consumption habits of the population, the increase in welfare levels, and the tendency to abandon rural areas to concentrate in urban centers. This has substantially modified the quantity and composition of MSW.

**Urban**, **Sustainability, Demographic analysis, Composition, Tendency**

**Resumen**

Este trabajo tiene el propósito de evaluar el Diagnóstico de los residuos sólidos urbanos (RSU) en el Estado de México, a través del marco de la sustentabilidad. Las áreas urbanas representan un foco de atención para las administraciones locales ya que representan espacios de importancia económica en el Producto Interno Bruto. Al mismo tiempo, en estas áreas se favorece la concentración de población y la contaminación del aire, agua y suelo en estas áreas. El análisis comprendió revisión documental y diagnóstico de los residuos sólidos urbanos (RSU) en el Estado de México, para lo cual es necesario investigar diferentes aspectos de suma importancia, así como algunos antecedentes que involucran no solo al estado, ya que para poder comparar es necesario conocer la gestión de RSU en México a nivel nacional primero para posteriormente enfocarnos en el Estado de México. Como sabemos, los RSU han aumentado con el paso del tiempo debido al crecimiento demográfico e industrial del país, al cambio de hábitos de consumo de la población, la elevación de los niveles de bienestar, y la tendencia a abandonar las zonas rurales para concentrarse en los centros urbanos. Lo anterior ha modificado de manera sustancial la cantidad y composición de los RSU.

**Urbano, Sustentabilidad, Análisis demográfico, Composición, Tendencia**

## 1. Introduction

At present, most of the world's inhabitants are focused on urban regions, presenting increasingly greater challenges to solve urban-environmental and governance problems, this is due to a hurried urbanization initiated since the mid-twentieth century, which formed localities that were not prepared for the requests of their inhabitants and its increase acquired a disorderly character , a problem that is causing a social, economic and environmental imbalance is the issue of urban solid waste that constitutes one of the greatest concerns of contemporary communities and a global challenge for public administration, and this problem is expressed as a global trend in the generation of urban solid waste, where the highest levels correspond to nations with economic incomes Such is the situation of the territory of North America, consisting of the USA, Canada and Mexico.

According to a study in the 2010 population census (INEGI 2010), it is suggested that 72% of the population of the territory inhabits more than 15,000 inhabitants. Recent projections of the urban phenomenon in Mexico, estimate that the population will reach 121 million individuals in the next 18 years, who will live in metropolises of more than one million inhabitants in 2030, growth and concentration will demand various inputs for its sustenance such as water, energy and materials, as well as the adequate disposal of waste discharged into water, air and soil, where inadequate dumping of solid waste alters the quality of these three resources, as well as their impact on human health and ecosystems. In Mexico, the transition from rural to urban changed the consumption patterns of a society that produced mostly organic waste, to one that generates primarily inorganic waste derived from the usual consumption patterns of urban industrial communities (SEDESOL, 2011) and in 2010 alone, the territory generated 109,750 tons of solid waste daily, of which 64% were deposited in landfills, 9% in controlled landfills, and the remaining 27% was disposed of in uncontrolled sites.

The management of municipal solid waste in most developing nations rests with local authorities, such as China, Turkey, India, Ethiopia, Uganda, Greece and Spain among others, (Kanat, 2010; Lohri *et al*., 2017; Okot-Okumo and Nyenje, 2011; Papachristou *et al.*, 2009) where the situation in Mexico does not flee to this condition, the "Political Constitution of the United Mexican States" points out that it is the responsibility of the municipal authorities to collect and operate it, since, although there are different policies, laws and programs aimed at providing a convenient operation, the lack of tools for its proper use and administration has made it possible to these programs are political-environmental discourses, where society is a scarcely participating observer. In this research, in order to know the administration of Urban Solid Waste (MSW) in the State of Mexico in conjunction with the Ministry of Environment and Natural Resources, SEMARNAT, information collection tools were used, such as observation, qualitative and quantitative research, focused on detecting the specific reasons for the incongruity between the formal and hence this chapter is divided into the following sections:

Section 1.1: Waste Management
Section 1.2: General Law for the Prevention and Integral Management of Waste (LGPGIR)
Section 1.3: Municipal Solid Waste (MSW)
Section 1.4: Management of municipal solid waste (MSW), special handling waste (SHW) and hazardous waste (HW) in Mexico.

Likewise, in section 2, the methodology is mentioned and in section 3 the results obtained during the research are presented.

## 1.1 Waste Management

The management of solid waste in Mexico goes through three moments in its history: it begins in 1964 under a predominant approach of sanitary regulation, in 1988 from the creation of national environmental legislation a step is taken towards the basic management of waste and in 2003 the creation of the General Law for the Prevention and Integral Management of Waste (DOF, 2003), by incorporating some aspects of sustainable management of municipal solid waste, in Table 1.1. The different approaches established in Mexican legislation are shown.

**Table 1.1.** Enghouse established in Mexican legislation: sanitary regulation, basic management and integral management of MSW, with respect to the conceptual framework of sustainable management.

| Conceptual framework: sustainable MSW management | Waste sanitary regulation (1964 -1987) | Basic waste management (1988 -2002) | Comprehensive MSW MAnagement (lowercase m) (2003-2012) |
|---|---|---|---|
| Production of goods and environment | Environment and development | The environmental issue is involved in the production of goods and services | Environmental responsibility is involved |
| Urban metabolism | Linear metabolism | Circular metabolism | Circular metabolism |
| Material Recovery | Recovery | Diversity of recovered by-products | Highlights the hierarchical management of waste through reduction, reuse and recycling |
| Infrastructure | Scarce physical and human resources | Scarce resources, with deployments for recovery | Scarce resources, with improvements in material collection |
| Legal framework | General legal framework for health management | Environmental legal framework for operational management | Sectoral legal framework for operational management |
| Public policies | Short-term operational actions | Operational and short-term public policies | Operational public policies for short-term pollution prevention |
| Innovation and research | Research is minimal and health-oriented | Preparation of technical studies, in accordance with official standards | Preparation of technical studies, and audits |
| Education and training | Educational axes if Environmental content and minimum training | Education activities Formal informal environment budding training | The contents are extended in the Basic educational axes and localized training |

*Source: Diagnosis of Urban Solid Waste Management in the Municipality of Mexicali, Mexico. Challenges for the Achievement of Sustainable Planning.*

Consequently, the sanitary regulation considered solid waste as an urban sanitation problem that was in charge of the public health authorities, its operation was specified in the collection and removal of waste from urban centers for disposal in rural areas with the traditional management of burning, on the other hand, the period of sanitary regulation includes from the appearance of the first federal rules of operation by the Ministry of Health and Assistance (SSA) in 1964, until the assignment of functions to public services in the municipalities in 1985, and that is modified with the publication of the General Law of Ecological Balance and Environmental Protection in 1988 (DOF, 1988), when establishing the official Mexican standards for final disposal sites.

In such a way that the basic annex assumes not only an operational policy of collection and final disposal, but also tasks of prevention of pollution by MSW, with the publication of the Law of Ecological Balance and Environmental Protection, in 1988, the first type of waste was built and rum was distributed. competences for the three levels of government, ratifying the formulation of environmental policy, the provision of the service of collection and management of MSW, to the municipalities, to itself also, appears the Official Mexican Standard specific in 1996 the sites of final disposal, and the construction of infrastructure by the federal government is accentuated, by manifesting the budgetary limitations that the municipalities had to build this type of infrastructure, the validity of this approach extends until before the publication of the first federal sectoral law (Gil, 2009).

Finally, the integral management of Urban Solid Waste is an approach that presents a comprehensive vision through the publication of the General Law for the Prevention and Integral Management of Waste (DOF, 2003), has a categorization into three groups of waste: municipal solid waste (MSW) of municipal competence, special handling waste (SHW) of state competence and hazardous waste (HW) of federal competence, based on this categorization local governments assume responsibility for municipal management, management that requires coordination and concurrence with other levels of government for pollution control under the signing of agreements. Thus, the integral management considers, attend the waste management system that includes the generation, storage, sweeping, collection, transfer, treatment, use of materials and final disposal, as well as include regulatory actions for the issuance of cleaning regulations, incentives for the reduction of garbage, the promotion of collection centers, management of resources and support, training, as well as impact assessments on the natural and social environment.

The State of Mexico ranks first nationally, by the number of its inhabitants 15,175,862, according to the 2010 population census, also has 13.5% of the national industry, highlighting the production of food, beverages, tobacco, among others, coupled with it social and commercial activities have increased; thereby generating a considerable increase in waste generation, A situation that is complicated by inadequate practices during the collection, separation and lack of use of recoverable materials that can be reincorporated into the production chain and used as raw material in production processes, a situation that is neglected by the high costs they require for their treatment, derived from the poor conditions in which they are found. (SEMARNAT, General Directorate of Solid Waste Management).

Similarly, the State of Mexico is the most populous entity in Mexico, with 16,187,608 inhabitants (INEGI, 2015), it is the territory with the highest generation of MSW in the country, around 10% of the total, its production is 1,046kg / inhabitant / day, above the national average of 0.852 kg (GEM, 2009). In addition, due to its geographical location, it experiences a variability of climates with strong variations in temperature and precipitation, which affect the processes of decomposition of organic matter, as well as the diffusion of water-soluble substances, which when available on slopes or landfills in the "open sky" are typical to spread the contamination of the same, These data show the magnitude of the problem, by dimensioning that each person produces about 1kg of waste, the excessive consumption of products is inferred or that they contain waste materials in excess, any of the cases speak of an irrational behavior before consumption.

### 1.2 General Law for the Prevention and Integral Management of Waste (LGPGIR)

The LGPGIR, defines MSW as those generated in dwelling homes, resulting from the elimination of materials used in their domestic activities, the products they consume and their containers, packaging and packaging; waste that comes from any other activity within establishments or on public roads and those resulting from the cleaning of roads and public places (LGPGIR, Article 5, section XXXIII).

On the other hand, the activities associated with the solid waste management process, from the point of generation to the final disposal, have been grouped into six functional elements Tchobanoglous (1997): a) Waste generation, b) Handling and separation of waste, storage and processing at source, c) Collection, d) Separation, processing and processing of solid waste; (e) Transfer and transport and (f) Emptying.

The Integrated Management of Municipal Solid Waste can be defined as the selection and application of techniques, technologies and management programs suitable to achieve specific waste management goals and objectives. The problems associated with MSW management in today's society are complex due to the amount and diverse nature of waste, the development of dispersed urban areas, the limitations of funds for the provision of the municipal public cleaning service, as well as the impacts of technology and emerging limitations of energy and raw materials (Tchobanoglous, 1997).

Consequently, the Integral Management of MSW must be carried out in an effective and orderly manner, identifying the relationships and the fundamental aspects involved, to obtain information with uniform data to support the design of both federal and state and municipal programs, in order to optimize resources, staff training, restructuring of operational and administrative methods and procedures, environmental awareness to achieve the committed participation of the population and the establishment of mechanisms to give continuity to projects and programs through institutional changes in the current municipal administration in the context of Integral MSW Management. Integrated MSW Management has to be considered as an integral part of Environmental Management.

The steps of this management are: reduction in the source, reuse, recycling, sweeping, storage, collection, transfer, treatment and final disposal. Within its local scope, this management must include all administrative, financial, legal, planning and engineering functions (technical aspects) involved in solving all problems associated with inadequate management.

### 1.3 Municipal Solid Waste (MSW)

Urban solid waste (MSW) is those that are produced in homes, whether houses, offices or small businesses, as well as those that come from any other activity that is carried out in establishments or on public roads, with domiciliary characteristics and those that occur in public places, provided that they are not considered as waste of another nature (DOF, 2003).

In Mexico, according to the most recent figures, published in 2017, MSW generation reached 44.6 million tons, which represented an increase of 35.6% compared to 2003 (11.73 million tons more generated in that period). If expressed per inhabitant, it reached 0.98 kilograms on average daily in the same year (Presidency of the Republic, 2017).

The amount of municipal solid waste generated can be explained as a result of multiple factors, recognizing among the most important urban growth, industrial development, technological modifications and changes in the consumption patterns of the population, among others.

In Mexico, as in the case of many other countries, the growth of MSW generation goes hand in hand with private final consumption expenditure and national, this relationship, which has also been observed in other regions of the world, means that, with higher incomes, the level of consumption increases and, as a result, a greater volume of waste is produced.

The generation of waste is also closely linked to the urbanization process, and it is generally recognized that this is accompanied by a greater increase in the purchasing power of the population, which leads to living standards with high levels of consumption of goods and services, which produces a greater volume of waste. By contrast, in small or rural communities, inhabitants base their consumption mainly on less manufactured products that generally lack materials that end up as waste.

Using the size of the population and the characteristics of the localities, the states that would be generating the most MSW would be the state of Mexico (6.98 million t; 15.7% of the national total), Mexico City (3.98 million t; 9%), Jalisco (3.2 million t; 7.1%) and Veracruz (2.4 million) Colima (241 955 t; 0.5%), Baja California Sur (301 640 thousand t; 0.7%), Tlaxcala (301 759 t; 0.7%) and Campeche (313 317 t; 0.7%).

### 1.4 Management of municipal solid waste (MSW), special handling waste (SHW) and hazardous waste (HW) in Mexico

In Mexico there are legal instruments that regulate the integral management of waste and that involve generators, those who transport them and those who process them, or not of these legal instruments is the General Law for the Prevention and Integral Management of Waste (LGPGIR; DOF, 2003), the National Program for the Prevention and Integral Management of Waste and the state and municipal programs for Prevention and Integral Management of Waste, however in the case of hazardous waste or another type of instruments to manage waste are inventories, which provide information for decision-making , in addition to collecting and integrating information on the sites where this type of material is collected, including those that no longer operate or are even clandestine, nevertheless solid waste management plans, through which generators (whether in the public, private or social sector) must adopt measures to reduce the generation of MSW, SHW and HW, take advantage of those susceptible to reuse, recycling or energy production, or to treat or confine those that cannot be recovered. Several instances are involved in waste management, see Table 1.2.

**Table 1.2** Waste management according to the instance involved.

| Instance | Responsibilities and roles |
|---|---|
| Secretary of Environment and Natural Resources (SEMARNAT) | Develop policies and strategies for environmental control.<br>Regulate and supervise the environmental regulatory framework.<br>Coordinate national programs for environmental management.<br>Promote the creation of infrastructure (in collaboration with Sedatu). |
| Secretary of Health (SSA) | Develop policies and strategies for health control.<br>Regulate and supervise health.<br>Develop plans for the prevention of occupational risks and risks to public health in the different stages of MSW management.<br>Coordinate national programs for environmental sanitation. |
| Secretary of Agrarian, Territorial and Urban Development (Sedatu) | Promote the creation of infrastructure (in collaboration with Semarnat). |
| Other secretaries | Support the management of MSW in their respective areas (tourism, industry, fisheries, energy and mines, transport, housing, others).<br>Regulation of MSW management in their respective areas of intervention. |
| Municipal governments | MSW management: sweeping, collection and final disposal.<br>Formulation of the local regulatory framework.<br>Application of penalties for non-compliance in the handling of MSW.<br>Formulation and implementation of mandatory fees for the services provided. |

*Source: Report on the Situation of the Environment in Mexico*

## 2. Methodology to be developed

### 2.1 Sustainable MSW planning

The proposal in general is built from the circular approach for solid waste that integrates compatible forms of production and consumption that consider the flows of matter and energy in the system, which refers to the use of waste via the reduction in consumption, reuse and recycling (Dálisa *et al*., 2012; Marshall and Farahbakhsh, 2013; Pires *et al*., 2011; Seadon, 2010).

### 2.2 MSW management in the State of Mexico

Currently, most rural municipalities limit the management of their solid waste to basic elements, so the generation, collection and final disposal should be monitored; in some cases, manual sweeping is also carried out in streets of the municipal capital, in Figure 2.1, the diagram of the management of the general MSW is observed.

**Figure 2.1** General diagram of MSW management


*Source: Program for the prevention and Integral Management of MSW and Special management of the State of Mexico*

### 2.3 Types of MSW Treatment

In this section, the identification of the different types of treatment of MSW in the State of Mexico was carried out, with respect to current regulations.

### 2.4 MSW generation in the State of Mexico

Based on the documentary research, the total amount of waste generated in the State of Mexico tons / month was estimated.

### 2.5 Regulations applied to MSW in the State of Mexico

The regulations covered by MSW within the State of Mexico, on which this study was based, are:

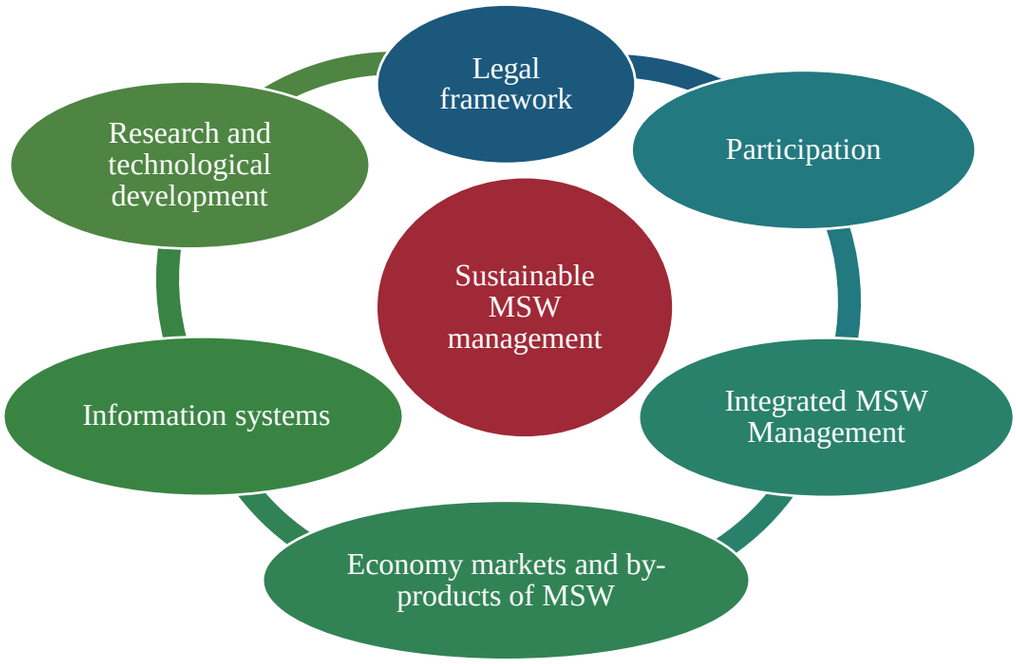
- Regulation of book 4 of the code for biodiversity of the state of Mexico.
- General Law of Ecological Balance and Environmental Protection
- General Law of Ecological Balance and Environmental Protection
- Code of Administrative Procedures of the State of Mexico
- Administrative Code of the State of Mexico
- Code for Biodiversity of the State of Mexico
- Rules of Procedure of PROPAEM.

## 3. Results

### 3.1 Sustainable MSW planning

The planning of MSW contemplates environmental restoration that involves the integration of new administrative and regulatory forms, the reengineering of public policies; the incorporation of technological innovation and the development of research, the promotion of educational and training cycles, the formation of market circuits, the formation of clusters, the participation of private initiative, the management and promotion of finances to the sector, investment funds; public participation; as well as the implementation of monitoring and evaluation (ICLEI, 2005, AUMA, 2006; Centro Complutense de Studio's e Information Ambiental, 2009), which implies analyzing the forms of management that have been carried out in Mexico, an example is the study carried out in the municipality of Mexicali, in Figure 3.1, the elements that form the framework for the planning of Urban Solid Waste from the approach of sustainability are presented.

**Figure 3.1** Diagram of the framework for planning Municipal Solid Waste from the approach of sustainability




*Source of Consultation: Own Elaboration*

According to the previous diagram, the competences and attributions of the orders of the government in the sector are described, referencing the federal, state and municipal regulatory structure; Institutional framework, presents the policies and actions concerning plans and programmers carried out by the council through the units related to the subject; Participation, integrates the different forms of participation in planning and management activities carried out by the actors, as well as the rights they have of access to information and mechanisms for disseminating actions for monitoring and evaluating the performance that should be carried out by the assembly, on the other hand, the groups involved in waste management, this analysis facilitates the identification of diverse profiles and opinions on the management system in which they participate: responsible, groups and organizations of the public, private and social sectors linked to the subject; Integrated MSW Management, provides basic information on generation, transfer and disposition; Infrastructure, reports the material resources and facilities available to carry out the work of waste management by the council; interactions, shows the actions of concurrence that the conjuncture has with the other levels of government, the waste of special handling and dangerous; Finance, provides the budgetary information for the operation of the service by the council; economy, considers the opportunities of new market niches for the use of solid waste by-products and of the economic and financial instruments available to enterprises.

The information systems creates databases associated with the planning and management of solid waste for better decision-making and actions for evaluation and monitoring of its performance and communication to society; Research and development, incorporates scientific and technological contributions aimed at the sustainable management of solid waste, as well as considers environmental education as the basis of cultural changes, such as the importance of the dissemination and communication of actions to society and the feedback they make to management and; Education and training, provides non-formal environmental education, trains its staff and implements technological innovation actions in the management of MSW.

### 3.2 MSW management in the State of Mexico

Currently, a large part of rural municipalities limits the management of their solid waste to the basic elements: generation, collection and final disposal; In some cases, manual sweeping is also carried out in the streets of the municipal capital.

a) Generation: The generation of waste is directly associated with the amount of population and the economic dynamics that characterize a community, municipality or region. According to INEGI, in 2010, the State of Mexico had a total population of 15,175,862 inhabitants, contributing 13.5% to the national total. As for the distribution of the population in the state, 87% is located in urban areas and 13% in rural areas. As a result of the amount of population accumulated by the State of Mexico and the diversity of economic activities, the demand for goods and services is very high, which leads to the generation and management of large amounts of urban solid waste. On the other hand, the INEGI, 2010. The State of Mexico generates approximately 6,798,100 tons of municipal solid waste per year, which represents 16% of the total waste generated nationwide.

b) Collection: Of all the processes that make up the Integrated Management of Urban Solid Waste collection regularly is the one that generates the highest costs and depends, to a large extent, on the type of collection that is carried out (mixed or separated waste) since this determines the type of subsequent treatment. Obviously, the collection of separated waste reduces costs. In Table 3.1, the municipalities that provided information have high percentages of waste collection in their localities.

**Table 3.1** Collection in municipalities of the State of Mexico

| Municipalities | Localities by municipality | Locations with Collection % |
|---|---|---|
| Temascalcingo | 66 | 91 |
| San Felipe del Progreso | 105 | Sd |
| Acambay, Ruíz Castañeda | 103 | 85 |
| **Municipalities** | **Localities by municipality** | **Locations with collection service %** |
| Aculco | 67 | 61.19 |
| Atlacomulco | 66 | 90 |
| Jilotepec | 66 | 63.63 |
| San Jose del Rincon | 139 | 86.33 |
| Timilpan | 27 | 70 |
| Gold | 44 | 93 |
| Ixtlahuaca | 64 | 85 |
| Jocotitlan | 60 | Sd |
| Total | 807 | 80.57% |

c) Transfer: When the final disposal sites are located at very long distances from the collection areas, transfer plants are installed. The complexity of the plants depends on where it is located, since it is necessary to comply with the sanitary rules, as well as with the NTEA-010-SMA-RS-2008. The use of transfer centers is low in the region that integrates the program, since most municipalities have a final disposal site and in which they dispose of their waste without the need to make use of a transfer center

d) Separation of by-products for recycling: The separation of waste into by-products, for treatment, protects the environment since the number of tons of waste for final disposal is reduced. In addition, the sale of recyclable waste can help municipalities economically, however, the industry is usually interested in large volumes, which small municipalities cannot meet, so the creation of an intermunicipal system is recommended. The General Law for the Prevention and Integral Management of Waste provides for at least two types of separations, primary and secondary, the first is to separate organic waste from inorganic waste and secondary refers to separate from inorganic waste those that are likely to be recycled. In some municipalities, with regard to the separation of by-products for recycling, there is a "Program municipal are la prevention and gestion integral of MSW and special handling", within which it is known that: "the municipality during the work of collection of urban solid waste, the recovery of certain by-products with commercial value is practiced by the operators of the service within collection vehicles, being the materials with greater demand the PET, glass, metals and cardboard. Once these materials are separated, operators go to collection centers for direct sale.

e) Final disposal: at this stage the waste would be deposited or permanently confined in sites and facilities whose characteristics allow preventing its release into the environment and the consequent effects on the health of the population and ecosystems and their elements, it is important to mention that the Official Mexican Standard NOM-083-SEMARNAT-2003, establishes the terms to which the location of the sites, the design, construction and operation of the facilities destined to the final disposal of urban solid waste and special handling, in landfills or in controlled confinements, must be subject, in this way the LGPGIR, points out that municipalities must regulate land uses in accordance with ecological planning and urban development programs, in which the areas in which the final disposal sites of urban solid waste and special management will be established will be considered. The landfill is the main option for the final disposal of waste used in the State of Mexico, and which consists of an infrastructure work that limits the impacts caused to the environment due to poor waste disposal, also in the State of Mexico according to the information obtained in the Consultation Portal of the Integral Waste System of the State of Mexico, the disposal of this waste is carried out both in landfills and in integral waste centers, each of these places depends on the municipality, in Table 3.2 they mention the municipalities that have a sanitary landfill and those that have an integral waste center are shown in Table 3.3, which would be the most prominent in the State of Mexico.

**Table 3.2** Municipalities of the State of Mexico that have a landfill.

| Name or business name | Municipality |
|---|---|
| Tecnosilicatos de México S.A. de C.V. | Ixtapaluca |
| Mexican waste concentrator S.A. de C.V. | Ixtapaluca |
| Constructora y operadora de rellenos sanitarios, S.A. de C.V. | Tenango del Valle |
| Chicoloapan landfill | Chicoloapan |
| Grupo contadero, S.A. de C.V. (Xonacatlán) | Xonacatlán |
| Tersa del golfo, S. de R.L. de C.V | Cuautitlan izcalli |
| Vigue relleno sanitario, S.A. de C.V | San Antonio de la Isla |
| RS Wast, S.A. de C.V. | Tecámac |
| MA. Carolina Villalobos Hernandez | Zumpango |
| Environmental Maintenance and Services, S.A de C.V. | Zinacantepec |
| Esmenra, S.A. de C.V. | Teoloyucán |
| Pro-faj hidrolimpieza, S.A. de C.V | Naucalpan de Juarez |
| H. city council of Tlalnepantla de Baz | Tlalnepantla de Baz |
| H. Atlacomulco city council | Atlacomulco |

**Table 3.3** Municipalities of the State of Mexico that have a comprehensive waste center

| Name or business name | Municipality |
|---|---|
| Tecnosilicatos de México S.A. de C.V. | Ixtapaluca |
| RS wast, S.A. de c.v. | Tecámac |

The final disposal of MSW in region II of the State of Mexico, there are final disposal sites, however, not all municipalities control the disposal.

### 3.3 Types of treatment

The treatments used in the State of Mexico are:

Biological treatment: This type of treatment is used for the elimination of gas and bad odor in the final disposal sites that is originated by organic waste, they are based on the degradation of organic matter present in the waste by the action of microorganisms, altering the molecular structure of the compounds eliminating toxic and dangerous compounds.

Other treatments currently used are the following:

a) Composted: This type of treatment according to the information obtained in, has only been reported by the municipality of Atlacomulco, however, it is not followed to the letter according to the stipulations of current regulations mainly consist of 20% waste by pruning, 60% organic waste and 20% manure.

b) Methanization: there is a biogas plant in the municipality of Atlacomulco that aims to provide municipal authorities with a tool to dispose of their urban solid waste in a sustainable ecological way,adthus also obtain economic benefit with the sale of the products obtained in this process. Fresh organic waste and municipal wastewater are treated which, through anaerobic fermentation, will producebiol (liquid fertilizer) biosolid (solid fertilizer) and biogas as a product.

c) Mechanical-biological treatment: it is a treatment that improves the properties of the waste that you want to deposit to reduce environmental impacts. It is a process that converts waste into semi-inert material through a broad stabilization phase, before final disposal, consists of two treatment stages: mechanic, to condition the MSW to its subsequent treatment and biological, through controlled fermentation or aerobic digestion.

There are also other types of treatment that are applied in many regions of the world, however, in Mexico there is little application mainly due to the high costs associated with these technologies. It refers to the chemical degradation of waste due to the increase in temperature caused by the combustion of most materials.

In the State of Mexico there are no plants of this type, due to the high cost of their installation and operation. Some of the heat treatments used in Mexico are:

1. Drying: it is the decrease in the weight of the waste, s and increases the temperature so that the water evaporates and thus reduces up to 50% the weight of the waste, s however, by increasing the temperature the volatile compounds are released causing an impact on the environment.

2. Incineration: process to reduce the volume and decompose or change the physical, chemical or biological composition of a solid, liquid or gaseous waste, by thermal oxidation, in which all combustion factors can be controlled. The incineration of MSW can reduce the volume by 70 to 90%.

3. Pyrolysis: thermal decomposition of a material in the absence of oxygen or any other reactant. This decomposition occurs through a complex series of chemical reactions and processes of transfer of matter and heat.

4. Gasification: optimized pyrolytic process, by which a solid or liquid substance with high carbon content, is transformed into a gaseous mixture of fuel, by partial oxidation with application of heat, process technology designed to obtain a synthesis gas; that is, a product that can be used to produce fuels, chemicals or energy.

5. Biomass reforming: heat treatment process, which with the help of a catalyst produces a hydrogen-rich gas from organic matter.

### 3.4 MSW generation in the State of Mexico

Table 3.4 shows the total amount of waste generated in the State of Mexico.

**Table 3.4** Waste generated: Integral Waste System of the State of Mexico (SIREM).

| Waste Management Destination | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Description of the Waste** | **Quantity generated (Ton/Month)** | **Use** | | **Treatment** | | **Gathering** | | **Final Provision** | |
| | | **Ton/ Month** | **%** | **Ton/ Month** | **%** | **Ton/ Month** | **%** | **Ton/ Month** | **%** |
| MSW-1 Solid organic waste (from food and gardening) | 712.675 | 68.315 | 9.586 | 3.608 | 0.506 | 8.582 | 1.204 | 632.170 | 88.704 |
| MSW-2 Recyclable solid waste, specify with form to classification | 180.249 | 5.583 | 3.097 | 1.371 | 0.761 | 4.120 | 2.286 | 169.175 | 93.856 |
| MSW-3 Medical waste | 477.580 | 4.259 | 0.892 | 2.985 | 0.625 | 15.601 | 3.267 | 454.735 | 95.217 |
| MSW-4 Other / specify | 104.931 | 3.966 | 3.780 | 1.380 | 1.315 | 0.000 | 0.000 | 99.585 | 94.905 |
| RME-1 Waste from health services generated by a large generator in Medical-assistance centers | 86.292 | 7.241 | 8.391 | 0.054 | 0.063 | 0.269 | 0.312 | 78.728 | 91.234 |
| RME-2 Agroplastic waste generated by intensive agricultural/forestry and forestry activities | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| RME-3 Organic residues from intensive agricultural/poultry activities / Livestock and fishing | 67.892 | 14.400 | 21.210 | 0.000 | 0.000 | 0.000 | 0.000 | 53.492 | 78.790 |
| RME-4 Waste from federal transport activities, which includes services in ports, airports, bus stations and motor transport stations and those of public transport, which includes service providers that have terminals, workshops or stations, which are included in The following list | 42.166 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 42.166 | 100.000 |
| RME-5 Sludge from wastewater treatment with the exception of those indicated in the NOM-052-SEMARNAT-2005 | 2,989.014 | 703.289 | 23.529 | 805.645 | 26.954 | 35.184 | 1.177 | 1,444.896 | 48.340 |
| RME-6 Waste from department stores or shopping centers, including self-service stores, supply centers, public markets and Travelling. | 10,905.351 | 8,842.732 | 81.086 | 50.000 | 0.458 | 0.000 | 0.000 | 2,012.619 | 18.455 |
| RME-7 Construction waste / maintenance and demolition in general that is generated in a work in a quantity greater than 80 $m^3$ | 418.839 | 44.767 | 10.688 | 0.000 | 0.000 | 0.000 | 0.000 | 374.072 | 89.312 |
| RME-8 Products that at the end of them Shelf life are discarded | 17,923.980 | 6,822.301 | 38.062 | 1,000.403 | 5.581 | 4,553.970 | 25.407 | 5,547.306 | 30.949 |
| RME-9 Others established in the General Law for Prevention and Management Integral Waste and Regulation | 14.464 | 0.000 | .000 | 0.000 | 0.000 | 0.000 | 0.000 | 14.464 | 100.000 |
| RME-10 Other | 10,594.455 | 1,987.168 | 18.757 | 2,125.346 | 20.061 | 44.332 | 0.418 | 6,437.609 | 60.764 |
| Total | 44,517.888 | 18,504.021 | 41.565 | 3,990.792 | 8.964 | 4,662.058 | 10.472 | 17,361.017 | 38.998 |

*Source: Integral Waste System of the State of Mexico (SIREM)*

With the data obtained previously, the result of the generation of MSW in the State of Mexico is 6,798,100 tons per year of municipal solid waste, representing 16% of the total waste generated nationwide with a population of 15,175,862. In Edo. Mexico has a population of approximately 16.99 million people, so it is estimated that, in 2021, there will be an increase in MSW generation of 7611,835 tons per year.

In this way it can be established that residue growth exists exponentially, given by the following formula: P (t) = (P0) ert, where the growth rate is:

Starting amount (P0): 15,175,862 people
Time (t): 10 years
Final quantity (P(t)):169,924,18
Growth rate: 0.0113061105282= 1.13061105282%

Therefore, using the same formula, with respect to waste generation and growth rate, the final amount generated per year is sought:

Initial amount (P0): 6798,100 tons per year
Time (t): 10 years
T growth rate: 0.0113061105282= 1.13061105282%
Final quantity (P (t)): 7611.835 Ton per year

In this way, the proposals in sustainable planning seek to reduce a large percentage in waste generation, so that together with the organizations and institutions responsible for the environment, greater impact must be generated to apply the management and regulations in force.

### 3.5 Proposal to improve MSW in the state of Mexico

In the country of Sweden, whose population is one of the largest in the Nordic countries, it is an exemplary country in the recovery of energy from waste, and this energy recovery is mainly based on the incineration of its waste, from which energy is provided for district heating of 20% of the country and for the electricity of some 250,000 families. Waste management in this country has become an industry and source of employment (Cali.gov.co, 2012).

However, the trend in Mexico is to increase the generation of waste, as well as its deficient final disposal, coupled with a lack of environmental culture and the clear devaluation that the majority of society gives to waste. On the other hand, the anaerobic conversion method is an environmentally safe option.

Likewise, the implementation of MSW treatment policies is a necessary alternative and improvement as an infrastructure for both society and the environment. The growing demand for MSW collection service requires an increase in the infrastructure with which it is able to properly handle MSW. However, with the passage of time, the location of the required infrastructure tends to move away from urban centers, so it is convenient to carry out comprehensive regional planning with long-term perspectives that allows the strengthening of the infrastructure for the management of MSW.

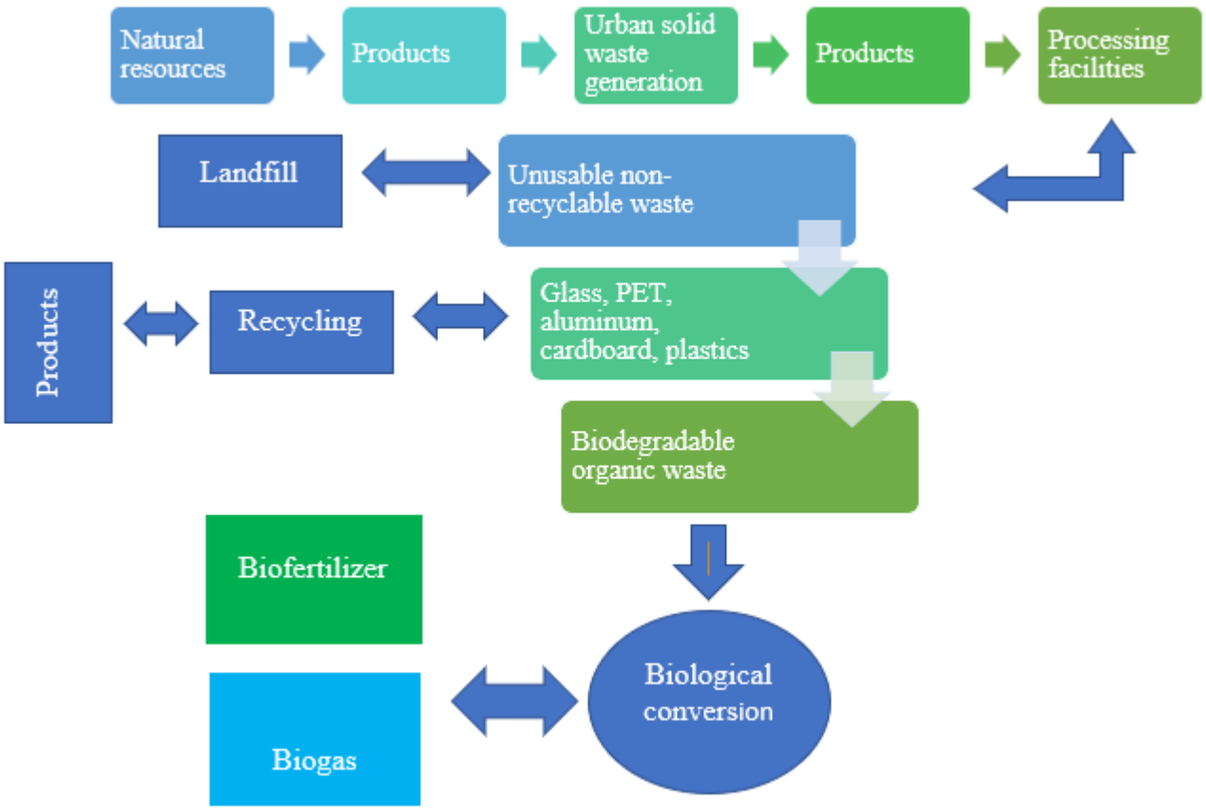
Comprehensive systems require collection and transportation systems, as well as infrastructure for waste treatment and separation. Currently, separation and treatment plants for MSW are becoming a necessary installation in large cities. In Mexico, growth rates are below expectations, as only 10% of the total MSW generated is recycled.

The capture of biogas is done through the biological conversion of organic waste by which different bacterial groups use this material to feed. This process of decomposition of matter generates a significant amount of methane gas, carbon dioxide, some nitrogen, hydrogen and hydrogen sulfide. The gas generated, biogas, can be used for heating or in electric generators. Through this process it is estimated that for each ton of organic waste, up to 175kWh can be generated, enough energy to power a standard refrigerator for two months (SENER, 2014).

At the global level, Germany and Sweden have set an example on this issue. In Germany there are more than 5,000 biogas plants throughout the country. In 2010 alone, these plants generated more than 13 TWh (billion kilowatt hours), representing approximately 2% of all renewable energy generated in the country. (IMCO, 2012).

On the other hand, the digested residue can also be very useful as a biofertilizer, since it has no odor and has characteristics similar to humus, favors the fixation of carbon in soils, and can improve the capacity of water absorption. Therefore, it is proposed to install an integrated MSW treatment plant with the capacity to capture biogas and biofertilizer production through anaerobic conversion. This treatment method favors the recycling and recovery of the materials that make up the MSW throughout the process: in the separation stage, inorganic waste is recovered to be recycled, which reduces the pressure on natural resources (extraction, production and transport of new products) and reintroduces these materials into the production system; In the stage of anaerobic digestion of the organic fraction, in addition to producing biofertilizer, methane emissions are reduced. Figure 3.2 shows a diagram of the conversion process of MSW to biofertilizer and biogas. Thus, from the primary products obtained with this waste treatment technology, a recovery of products or energy can be made at a later stage, and in this way a direct impact is achieved in the reduction of greenhouse gas emissions.

**Figure 3.2**. Process of conversion of MSW to biofertilizer and biogas




*Source of Consultation: Own Elaboration*

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**Conclusions**

The generation of MSW in Mexico and in particular the State of Mexico, highlighting the different processes that are applied for the reduction of these through different processes by previously defined category are important for an improvement of life not only municipal, state and national.

Carrying out this research is a reflection and is an awareness to reduce individually the garbage generated day by day, since, according to the statistics published by the government, the numbers are really high and although it seems that we have the opportunity and the obligation to create solutions to these problems, A high potential is really needed, since controlling waste generation is an unstable parameter at this time. The purpose is that the proposal of a turn of change in people so that they can and know what to do with waste.

The generation of Urban Solid Waste (MSW) is already becoming a serious problem for society, the environment for example in the pollution of seas, rivers and mainly in the quality of drinking water. According to the diagnosis made to the MSW generated in the State of Mexico, data is obtained where it has not been intended to reduce it, although there are laws and institutions, the legal framework in charge of applying is not reflected 100% for various reasons (politics, corruption, bad habits, lack of responsibility, etc.), this can be clearly observed in the final disposal sites since of the few sites that exist in the State of Mexico these do not comply with the stipulations of the rules, that is, they are not controlled, it was also realized that the treatments that must be used in the different types of waste, as mentioned in the document, are not used in most cases, and the only municipality that has reported the use of one of them, is the treatment by composting in the municipality of Atlacomulco, Edo. of Mexico, so it is really necessary to look for alternatives that can be used effectively and thus reduce the generation of waste in the State of Mexico, which surprisingly is the state with the highest generation of MSW in Mexico and is something really worrying. It is important to mention that it is everyone's task from the municipalities where planning should be applied mainly, to the citizens.

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