DOKUZ EYLÜL UNIVERSITY

GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

SOLID WASTE MANAGEMENT AND WASTE MINIMIZATION APPLICATION FOR BEER INDUSTRY

by

Ceyda KİDER

October, 2006

İZMİR

SOLID WASTE MANAGEMENT AND WASTE MINIMIZATION APPLICATION FOR BEER INDUSTRY

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M.Sc THESIS EXAMINATION RESULT FROM

We have read the thesis entitled **“SOLID WASTE MANAGEMENT AND WASTE MINIMIZATION APPLICATION FOR BEER INDUSTRY”** completed by **Ceyda KİDER** under supervision of **Yrd. Doç. Dr. Enver YASER KÜÇÜKGÜL** and we certify that in our opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Science.

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SOLID WASTE MANAGEMENT AND WASTE MINIMIZATION APPLICATION FOR BEER INDUSTRY

ABSTRACT

The technological developments, which are unavoidable in today's world, have provided better life standards for human beings. However, the developments have brought the increase in the amount of the waste generated. That is why researches are towards minimizing the wastes.

Industrial waste management has gained importance as an essential part of a fully integrated management strategy. For many companies, implementing waste management systems is a tool for understanding the current and potential impacts of the organization and obtaining potential savings by keeping wastes under control.

Waste management requires leading the waste through steps, which are determined to be best for the situation of the facility. It requires knowing what and how much waste is generated, knowing the true costs those wastes are adding to product pricing, and estimating the risks that they represent as they are presently handled. Waste management is not reacting to those process residuals, but rather proacting on them. Proacting includes elimination or minimization of wastes at their source.

Sustainable economic development is necessary to improve the standard of living and quality of life in the development countries. It is also required to maintain or enhance their attributes for those lands already commercially developed. Past experience indicates that one of the most important elements in the economic growth is the development of industry. It should be also recognized that developing industry, if pursued according to the traditional means, entails the additional inefficient consumption of limited national resource and generation of large amount of residue that called industrial pollution.

In general, industry has three generations of polluton problems. The first generation pollution problem is from the manufacturing facilities. The second-generation pollution problem is related to the use of the products after leaving the site of manufacturing. The final disposal of the used or unused products represents the third generation pollution problem for industry.

Today's rapidly changing technologies, industrial products and practices may generate wastes that, if improperly managed, could threaten public health and the environment. Industrial pollution is created when factories release harmful process by-products ans wastes into the environment. Many wastes, when mixed, can produce a hazard through heat generation, fire, explosion or release of toxic substances. These wastes are generally considered incompatible. Waste generators should describe and characterize their wastes accurately, by including information as to the type and the nature of the wastes, chemical compositions, hazardous properties, and special handling instructions.

This factory is giving the packing wastes which are formed in production process to CEVKO which is the authorized institute by Turkish Ministry of Environment and Forestry. These factories delegates the authority about collecting the packing wastes, reaching recycling targets and preparing "Waste Management Plan" to CEVKO via paying Green Dot fee.

In this study, amount of wastes in a beer industry and the sources of these wastes are analysed and observed on department basis. It is mentioned that in which department wastes are formed mostly and the reasons of it. A solid waste management is tried to be applied and than wastes are minimized in the same manner. For waste minimization, minimization on the source is considered instead of minimization of wastes formed due to production.

Keywords: Solid waste, waste management, recycle, beer industry, waste minimization.

KATI ATIK YÖNETİMİ VE BİRA ENDÜSTRİSİNDE

ATIK AZALTIM UYGULAMASI

ÖZ

Günümüzde kaçınılmaz olan teknolojik gelişmeler insanoğluna daha iyi yaşam şartları sağlamıştır. Buna rağmen, bu gelişmeler oluşan atıkların artışını da beraberinde getirmiştir. Bundan dolayı atıkların azaltılması için araştırmalar yapılmaktadır.

Endüstriyel atık yönetimi, entegre yönetim sistemlerinin önemli bir parçası olarak önem kazanmaya başlamıştır. Birçok firma için atık yönetimi stratejileri uygulamak, organizasyonun mevcut ve potansiyel etkilerini anlamak ve atıkları kontrol altında tutarak ekonomik tasarruf sağlamak anlamına gelmektedir.

Atık yönetimi, atıkların tesisin içinde bulunduğu duruma uyacak şekilde belirlenen adımlarla yönlendirilmesini gerektirir. Bunun için ne tür ve ne kadar atık üretildiğini, bu atıkların ürün fiyatlandırılmasına ne kadar yansıyacağını ve kontrollü veya kontrolsüz olarak getirebilecekleri riskleri iyi bilmek gereklidir. Atık yönetimi, atıkların proses sonrası değerlendirilmesini araştırmak yerine, oluşmadan önce çaresini araştırmaktır. Bunun yöntemi, üretilmesine tamamen engel olmak veya kaynakta azaltmaktır.

Kalkınmakta olan ülkelerde yaşam standardını ve kalitesini yükseltmek için sürdürülebilir ekonomik gelişme şarttır. Ayrıca ticari olarak gelişmiş ülkeler için de niteliklerini sürdürebilmek gereklidir. Geçmiş tecrübeler ekonomik büyümenin en önemli elementlerinden birinin de endüstriyel gelişim olduğunu göstermiştir.

Genellikle endüstride 3 tip kirlenme probleminden söz edilebilir. Birinci tip kirlenme üretim aktivitesinden kaynaklanır. İkinci tip kirlenme üretim sahasını terk ettikten sonra kullanılan ürünlerle ilgilidir. Kullanılan ve kullanılmayan ürünlerin son atıkları üçüncü tip kirlenmeyi oluşturur.

Günümüzün hızla değişen teknolojileri, endüstriyel ürünler ve aktiviteler doğru yönetilmedikleri taktirde halk sağlığını ve çevreyi tehdit edebilirler. Fabrikalar cevreye zararlı maddeler , ürünler ve atıklar bıraktıklarında endüstriyel kirlenme oluşur. Birçok atık birleştiklerinde ısınma, yangın patlama veya toksik maddelerin oluşumu gibi tehlikeler yaratabilirler. Atık üreticileri , atıklarını atık yapısına, kimyasal bileşenlerine, tehlikeli özelliklerine ve kullanım özelliklerine göre kesin bir şekilde tanımlamalı ve karakterize etmelidirler.

Tez kapsamında incelediğimiz işletme, üretim faaliyetleri sonucu oluşan ambalaj atıklarını Çevre ve Orman Bakanlığı'nca yetkilendirilmiş kuruluş olan ÇEVKO' ya vermektedir. Bu tür Yeşil Nokta **(Green Dot)** ücreti ödeyerek ÇEVKO sistemine katılan ekonomik işletmeler; ambalaj atıklarını geri toplama ve geri kazanma hedeflerine ulaşma, ambalaj atıklarının kaynağında ayrı toplanması ile ilgili "Atık Yönetim Planı" hazırlama, Bakanlığa karşı olan belgelendirme yükümlülüklerini ÇEVKO' ya devreder. Yeşil Nokta'yı ambalajlarında kullanarak işaretlemeyle ilgili yükümlülüklerini yerine getirirler.

Bu çalışmada, bir bira endüstrisinde oluşan atıkların miktarları, nerelerden kaynakladığı belirlenmiş, bu atıklar departman bazında incelemeye alınmıştır. Atıkların en çok hangi bölümlerden çıktığı ve bunun nedenleri üzerinde durulmuştur. Veriler doğrultusunda fabrika içinde bir katı atık yönetimi uygulanmaya çalışılmış, bu doğrultuda atık azaltımına gidilmiştir. Atık azaltımında, üretim sonucu oluşan atığı azaltmak yerine özellikle kaynağında atık azaltımına önem verilmiştir.

Anahtar sözcükler: Katı atık, atık yönetimi, geri kazanım, bira endüstrisi, atık azaltımı.

CONTENTS

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CHAPTER ONE
INTRODUCTION

Solid wastes are have been one of the most significant environmental problems that the world is facing. Uncontrolled increase of the world population, changing the life standard of the people and development of new products to supply the public demand are some of the reasons causing the increase of the amount of the solid wastes generated.

Turkey has been combating with the same problem, changing the institutional structure of the national policy and the necessary legislation about the solid waste management and the implementation of the recycling-recovery programs to reduce the amount of the solid waste to be disposed at the sanitary landfills are the immediate actions to be applied to solve the solid waste problem.

The solid wastes have different structural components, effects in a different way and treatment by different processes due to their sources, produced.

Disposal of solid wastes is one of the most important environmental problem of today. Production of solid wastes begins with obtaining raw materials and they continue to be produced in every step of production processes. Domestic wastes, commercial, industrial and agricultural wastes and treatment plant sludge are defined as solid wastes.

In Turkey, collection and transportation stages of solid waste management are generally well organized, but disposal of the collected wastes from municipal, industrial and agricultural sources is worse situation. Most of the settlement units and industrial organizations dump their collected solid wastes to the nearest lowlands and river valley or directly into the sea environment without any prior treatment. Hereford, solid waste disposal as ‘open dump’ to the areas poses serious environmental problems and consequently many risks for public health.

Waste reduction (waste minimization, reuse, recycling, recovery and composting) is an integral part of national waste management strategy. Separation and recycling of secondary materials from municipal solid waste is already well established in Turkey. There are several kinds of waste materials that should be recovered from solid waste. The major materials include; glass bottles, paper and paper products, plastics products, can bottles such as steel and aluminium, metal including copper, iron, steel, aluminium.

The topic ‘recycling of solid waste’ involved in the regulation, impose some responsibilities on producers for recollection and evaluation of liquid food packaging of ‘use-dispose’ type, in accordance with the ‘polluter pays’ principle in the Environmental Law. Nowadays economic tools such as tax, quota, and involvement share are being used for waste disposal. In Turkey, ‘quota-deposit’ among economic tools was begun to be used in order to reduce environmental pollution originating from packaging wastes.

Industry produces goods, utilizing raw materials and energy obtained from natural resources, for the need and benefit of the society. As a result of this manufacturing activity, some unwanted by-products, in other words “wastes” are generated. As well as being wastage of the natural resources, wastes are actually loss of money to the industrialists. These wastes, which are released into the receiving media, are the sole reason of environmental pollution of today’s world.

Industrialists should give waste management the highest priority in environmental protection efforts. Wastes should be taken under control with steps that are determined to be best for the situation of the individual facility. Waste surveys to identify each source and quantify the amounts should be carried out as a first step to take wastes under control. Waste generation must be avoided as much as possible by using techniques of waste minimization.

Industrial wastes can best be minimized through education, planning, better management and government enforcement. Whatever the triggering factor is, once the minimization program is implemented and carefully carried out, industrialists witness that the program has many benefits ranging from increasing operating efficiency to competitive advantage caused by the improving environmental image of the company.

In this study, amount of wastes in a beer industry and the sources of these wastes are analysed and observed on department basis. It is mentioned that in which department wastes are formed mostly and the reasons of it. A solid waste management is tried to be applied and than wastes are minimized in the same manner. For waste minimization, minimization on the source is considered instead of minimization of wastes formed due to production.

CHAPTER TWO
SOURCES, COMPOSITION & CHARACTERISTICS OF SOLID WASTES

2.1 Definitions

The sources of solid waste in a community are generally related to land use and zoning. These wastes can be grouped or classified in several ways, but classifications are necessary to address effectively the complex challenges of solid waste management. As a basis for later discussion, solid waste is divided into four general categories:

- municipal waste
- industrial waste
- agricultural waste
- hazardous waste

2.2. Sources of Solid Wastes

2.2.1 Sources of Municipal Wastes:

Municipal solid waste includes waste from household, institutional, commercial, municipal and industrial sources (Shah, 2000).

Residential Waste: This category of waste includes the rejected solid material that originates from single-family, multifamily, and high-rise dwellings. These wastes are often called household wastes, and they consist of garbage, rubbish and trash, bulky waste, and ash.

Garbage: This type of waste results from food preparation, packaging, consumption, and associated activities. Most of this waste is putresciple.

Rubbish and Trash: This category consists of paper and paper products, cans, bottles, plastics, old clothes, leather products, metal products, glass, ceramics, dirt, dust, garden wastes.

Bulky Waste: This category includes heavy and large wastes, such as appliances, furniture, mattresses, toys, tires, consumer electronics and similar items. Because of the size, weight, and irregular generation of these items, special handling and collection techniques are needed.

Ash: This waste is the end product from burning firewood, coal, and so on for the heating of residential units (Shah, 2000).

2.2.1.1 Municipal Solid Waste in Turkey:

Data about the current status of drinking water network, sewerage, treatment plants, solid waste services and solid waste disposal facilities of all municipalities in Turkey have been collected within the scope of Environment Statistics for Municipalities, since 1994 (The State Institute of Statistics [SIS], 2003).

According to the results of municipal solid waste statistics, 2915 municipalities out of 3215 were collected in 2001.

In the 2915 municipalities receiving solid waste services. From these results, 12.5 million tonnes in summer, 12.6 million tonnes in winter and 25.1 million tonnes of yearly average of solid waste were collected. Daily amount of solid waste per capita is calculated is as 1.28 kg/capita-day in summer, 1.32 kg/capita-day in winter and 1.31 kg/capita-day for yearly average. Besides, amount of solid waste collected by population group is shown in the Figure 2.1.

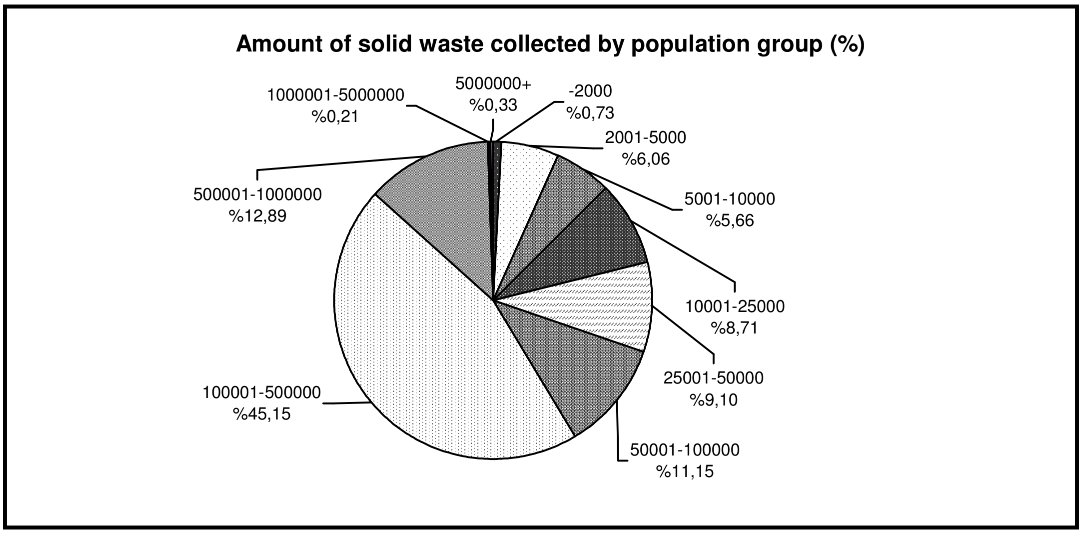


Figure 2.1 Amount of solid waste collected by population group (%), (SIS, 2003).

Of the 25.1 million tonnes of solid waste collected in 2915 municipalities in 2001, 40% (10.1 million tonnes) were disposed of in municipality dump, 33% (8.3 million tonnes) were disposed of by controlled landfilling, %15 (3.7 million tonnes) were disposed of in metropolitan municipality dump, %2 (482 thousand tonnes) were disposed of by burial, 1% (344 thousand tonnes) were disposed of by burning in an open area, 1% (218 thousand tonnes) were disposed of in composting plant, 0.4% (101 thousand tonnes) were disposed of into rivers, as seen in Figure 2.2.

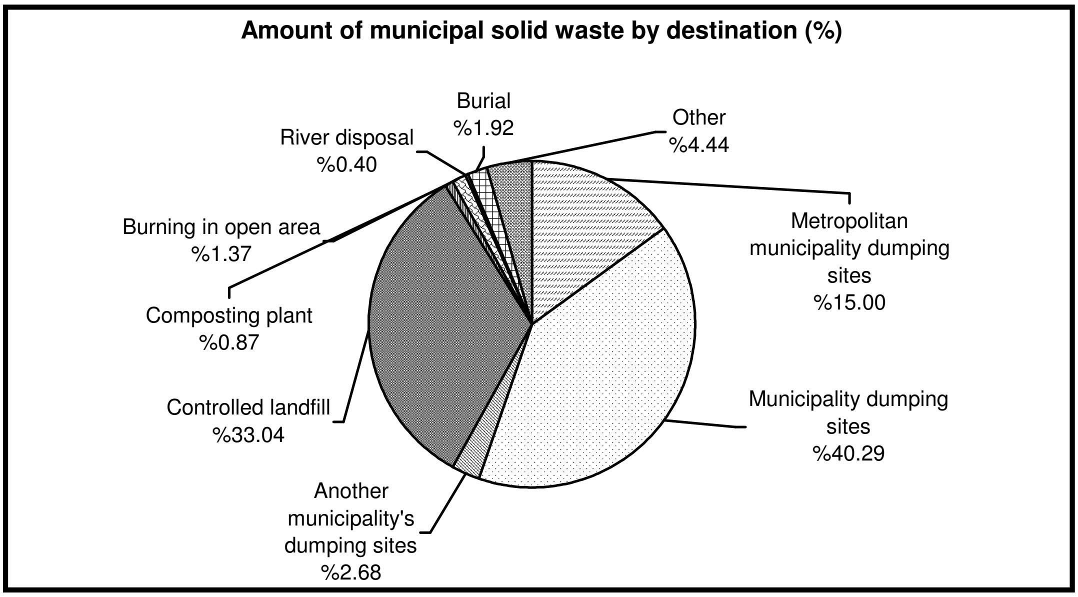


Figure 2.2 Amount of municipal solid waste by destination (%), (SIS, 2003).

In the same period it was determined that the number of municipalities, in which medical waste was collected separately were 432 and the amount of medical waste collected was 71 thousand tons. Of this amount, 18% was disposed of by controlled landfiiling and 15% by inceneration plants.

2247dumping sites were in operation in 2001. There were agricultural land near 1105 dumps, forest near 629 residental area near 351 dumps, pasture near 614 dumps, water resources near 137 dumps, touristic facilities near 23 dumps within 1000 metres distance from the dumping site (SIS, 2003). In Table 2.1 main environmental indicators of 2001 municipal solid waste statistics are stated.

Table 2.1 Main environmental indicators of 2001 municipal solid waste statistics (SIS, 2003)

Main Indicators	**2001**
Number of municipalities	3215
Number of municipalities receiving solid waste services	2915
Amount of solid waste collected (million tonnes/year)	25.1
Average amount of solid waste per capita (kg/capita-day)	1.31
Amount of average solid waste per capita in summer season (kg/capita-day)	1.28
Amount of average solid waste per capita in winter season (kg/capita-day)	1.32
Share of population receving by solid waste services in total population (%)	77.44
Share of population receving by solid waste services in total municipal population (%)	98.32
Solid waste disposal plants	
Share of population served by solid waste disposal plants in total population (%)	23.63
Controlled Landfill Sites	
Number	12
Capacity (million tonnes)	261.3
Amount of solid waste disposed of (million tonnes /year)	8.3
Amount of medical waste disposed of (thousand tonnes /year)	13
Composting plant	
Number	3
Capacity (thousand tonnes/year)	299
Amount of solid waste disposed of (thousand tonnes /year)	218
Incineration plant	
Number	3
Capacity (thousand tonnes/year)	44
Amount of medical waste disposed of (thousand tonnes /year)	11
Number of municipalities that cannot satisfy Solid Waste Control Regulation	
Do not have an idea about the regulation	942
Insufficiency of financial sources	1768

2.2.1.2 Municipal Solid Waste in the European Union:

From 1995 to 2003 municipal waste generation in EU 25 has constantly grown by about 2 % per year from 204 million tonnes (457 kg/person) in 1995 to 243 million tonnes (534 kg/person) in 2003. Generation is higher in the old Member States with 574 kg/person compared to 312 kg/person in the New Member States (NMS).

The comparison of old and new Member States in Figure 2.3 shows that the overall growth of municipal waste generation results from the development in the old EU Member States. Waste generation increased in EU 15 by 23 % from 482 kg/ person to 577 kg/person within the reference period. In contrast, the data suggest a slightly decreasing trend in the new Member States since 1999. In 2003, generation amounted to 312 kg/person in NMS 10 as compared to 334 kg/person in 1995 (Anonym, 2005).

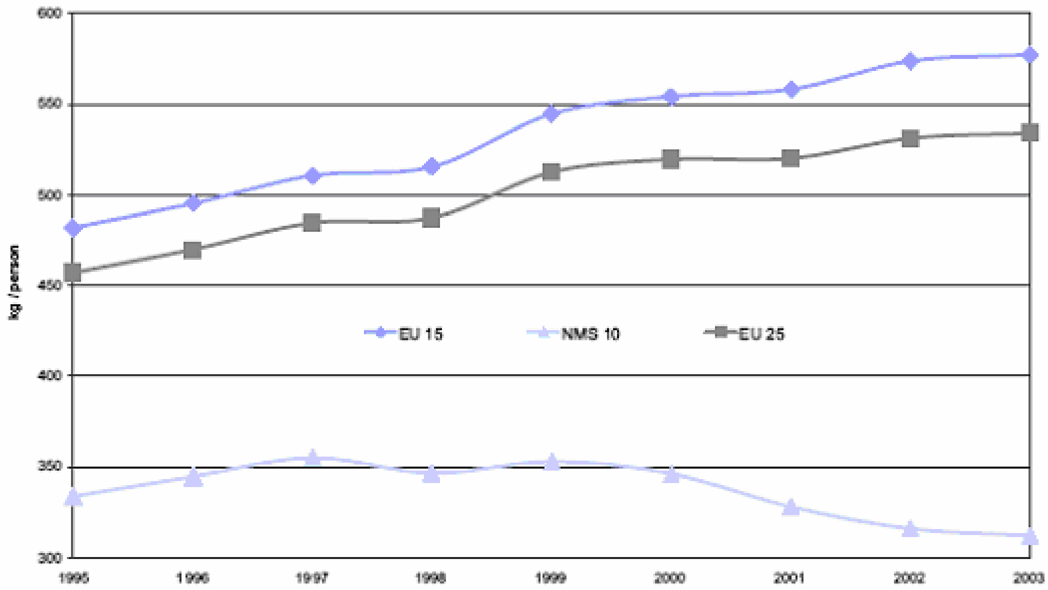


Figure 2.3 Generation of municipal waste in the European Union from 1995 to 2003 (kg/person)

Figure 2.4 shows the indicators on municipal waste generated by countries for the year 2003. The indicate the development in recent years Figure 2.4 compares the arisings 1995 and 2003. The generated totals in 2003 vary considerably between countries ranging from 260 kg/person in Poland to 1040 kg/person in Iceland. With the exception of Belgium, all EU 15 countries report considerable higher amounts for 2003 than for 1995. The same applies to the EFTA states Iceland, Norway and Switzerland. In the new Member States and the Candidate Countries the development differs from country to country. Clear increases are reported by Malta, Latvia, Cyprus, and Estonia. Most other countries report declines in municipal waste generations that are highest in Bulgaria, Slovenia and Lithuania.

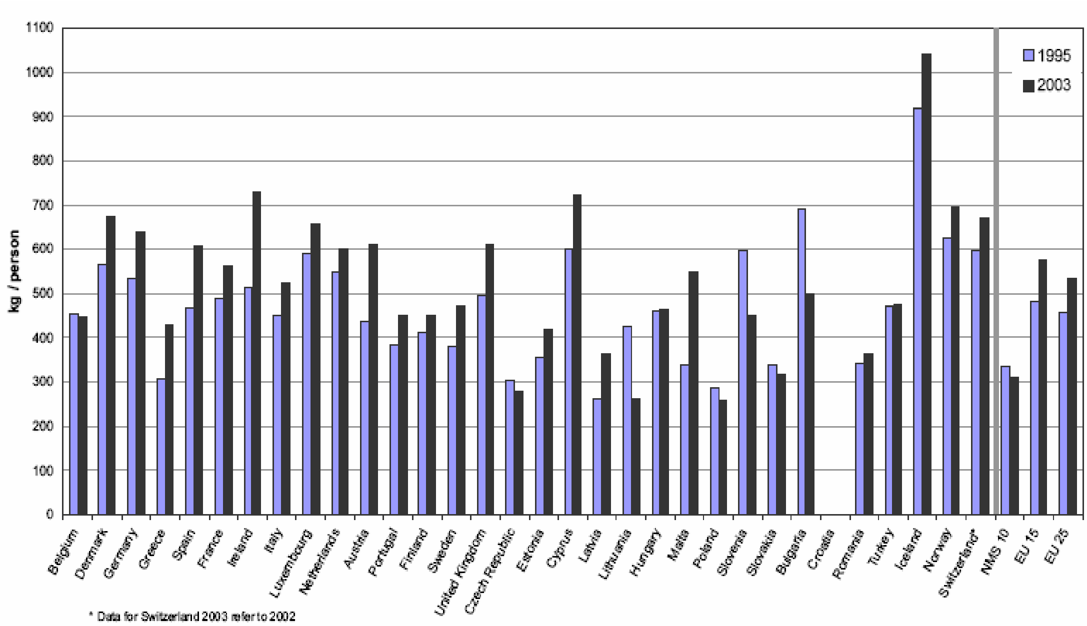


Figure 2.4 Municipal waste generation by countries and the European Union for 1995 and 2003 (kg/person)

Table 2.2 Abbreviations

Abbreviation	**Definition**
EU 15	Belgium, Denmark, Germany, Greece, Spain, France, Ireland, Italy, Luxembourg, Netherlands, Austria, Portugal, Finland, Sweden, United Kingdom (Old Member States)
NMS 10	Czech Republic, Estonia, Cyprus, Latvia, Lithuania, Hungary, Malta, Poland, Slovenia, Slovakia (New Member States)
EU 25	EU 15 + NMS 10
Candidate Countries	Bulgaria, Crotia, Romania, Turkey
EFTA	European Free Trade Association
EFTA Countries	Iceland, Norway, Switzerland
GVA	Gross Value Added
OECD	Organisation for Economic Co-operation and Development

2.2.1.3 Municipal Solid Waste in the United States:

Changing quantities and composition of municipal solid waste generation are illustrated in Figure 2.5. Generation of MSW has grown relatively steadily, from 88.1 million tons in 1960 to 231.9 million tons in 2000 (Environmental Protection Agency [EPA], 2000).

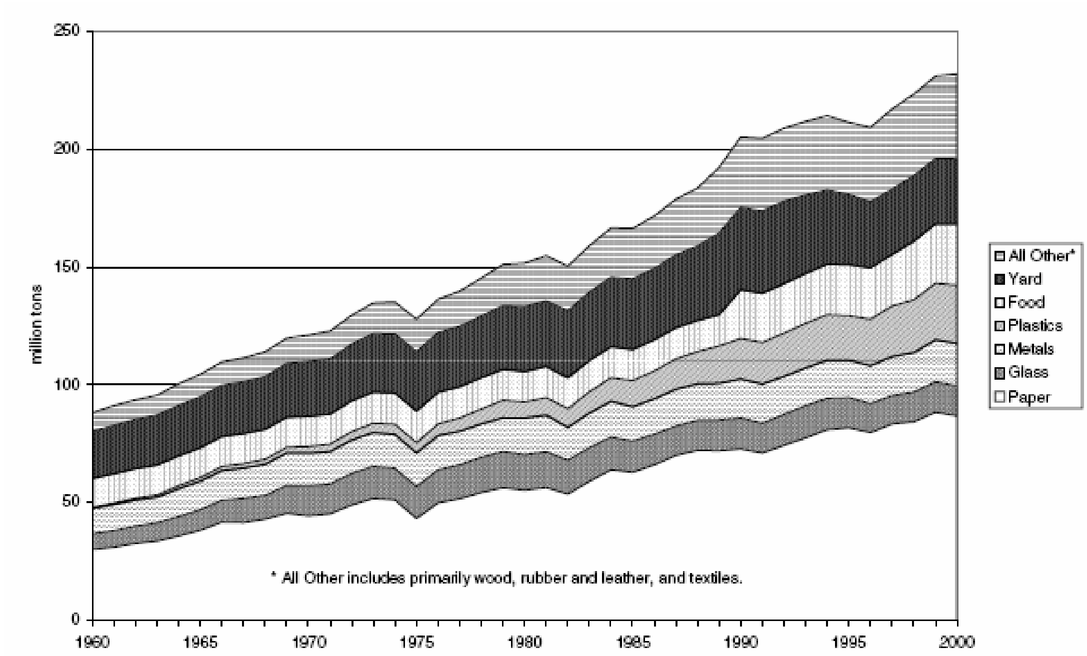


Figure 2.5 Generation of materials in MSW, 1960 to 2000.

2.2.2 Sources of Industrial Wastes:

Industrial process wastes are excluded from the category of municipal wastes (though wastes such as corrugated boxes, office papers, cafeteria wastes, wood pallets, and so on are included). There are two general sources of solid waste at industrial sites: the commercial and institutional components, and the process solid waste.

Commercial and Institutional Waste: This type of waste is generated by office, cafeteria, and other personnel-related activities. These wastes are included in the category of municipal waste.

Process Waste: These wastes are generated by various industrial processes. These industries include chemical plants, refineries, electrical, printing, wood, and many others. Some of this waste may be hazardous and is handled accordingly. Much of this waste is managed on site by the generating industries, but some is landfilled. The end product from an industrial process may be less than the input, but the balance of the material may end up as solid waste. Because of economic considerations and waste reduction efforts, secondary products are manufactured by recovering a certain portion of this waste (Shah, 2000).

The Figures 2.6 and 2.7 display the waste amounts generated by the manufacturing industries by country. The two graphs show different characteristics. Figure 2.6 indicates that waste generation per valued added is generally higher in the New Member States and the Candidate Countries. The highest values in 2002 are reported by Romania, Poland and the Slovak Republic (> 1500 kg/1000 EUR GVA). In EU 15 all countries fell below 500 kg/1000 EUR GVA in 2002 (GVA: Gross Value Added). For some countries like Finland, the Czech Republic, and Poland the figures per GVA indi- cate a steady decline of waste generation in comparison to the production output.

The figures on waste per person show no general differences between old and new Members. The highest waste arising is reported by Finland and Sweden with values over 2 000 kg/ person in 2002. The high amounts result form the strong wood, pulp and paper industry in these two countries. Most other countries generated between 300 and 1 500 kg/person. The EU 25 average amounted to 944 kg/person with an arising of 1 054 kg/person in the new Member States generating and 922 kg/person in EU 15.

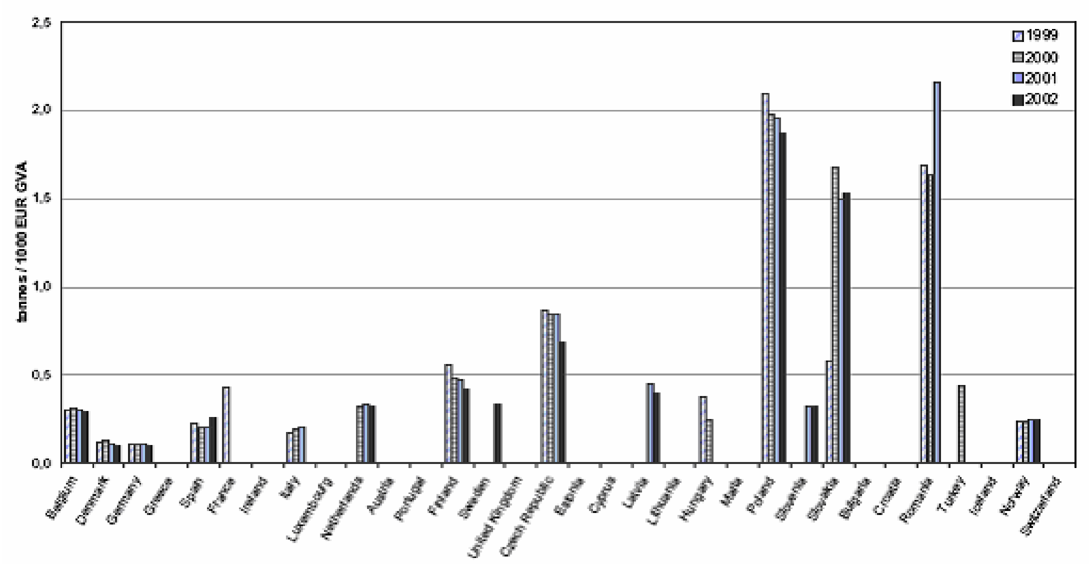


Figure 2.6 Waste generated by the manufacturing industry (15-37) by countries from 1999 to 2002 (tonnes/1000 EUR GVA)

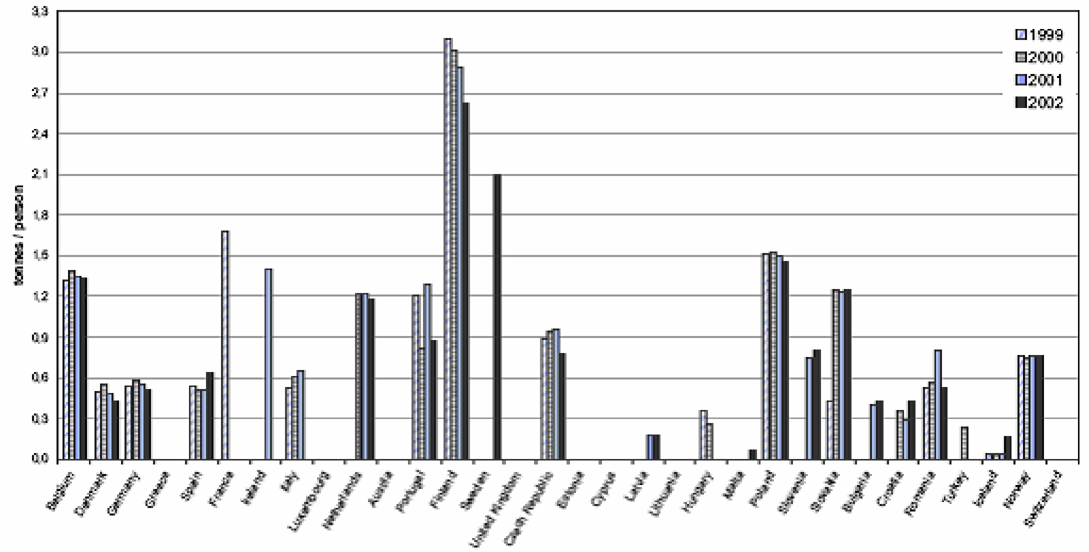


Figure 2.7 Waste generated by the manufacturing industry (15-37) by countries from 1999 to 2002 (tonnes/person)

The analysis of data on the country level revealed, that data on waste generation by sub-sectors for the year 2002 related to GVA were only available for five countries. Thus, it was abstained from presenting these figures. However, a country comparison regarding the origin of waste from manufacturing industry is possible for 12 countries, which is presented in figure 2.8.

In figures 2.8 and 2.9 all countries with detailed data on sub-sectors were plotted, but only those sub-sectors are shown in the figure with a share of more than 10% of the total waste generated in the manufacturing industry. Sub-sectors of a smaller share were included in the position “other manufacturing industries”. Where the sum of the sub-sectors fell below the section total, the difference was assigned to “other manufacturing industries” (Anonym, 2005).

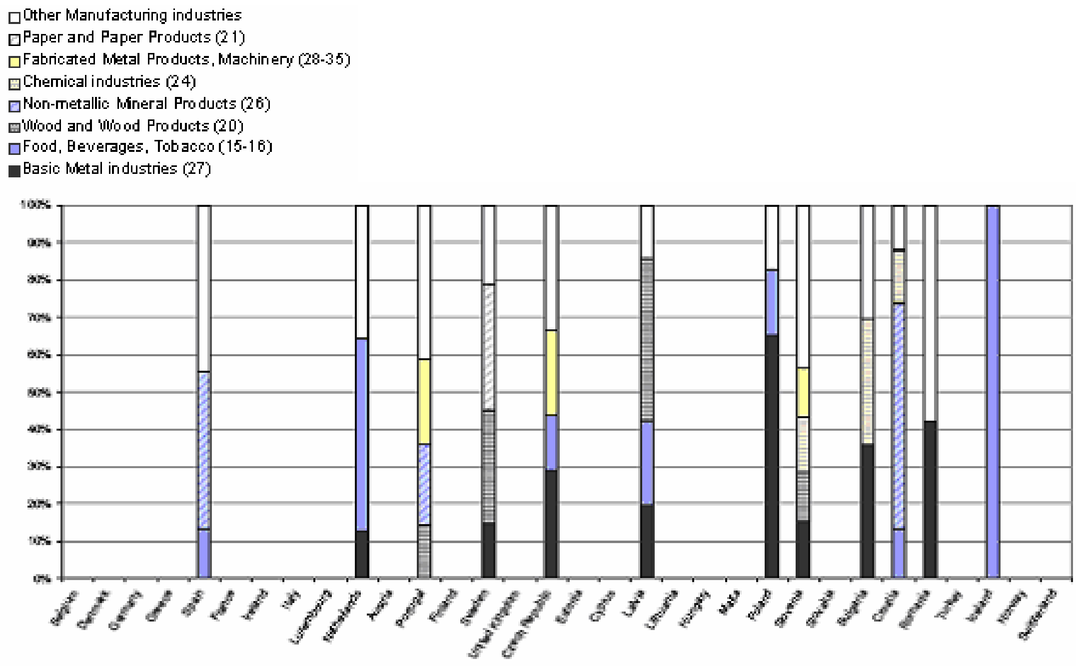


Figure 2.8 Waste generated by the manufacturing industry (15-37) by countries and sub-sectors for 2002 (%)

Figure 2.8 and 2.9 illustrate that the sub-sectors basic metal industries and food, beverages, tobacco are represented most often as significant sources of waste within the manufacturing industries of the various countries. Base metal industries contribute a particularly high share of waste in Poland, Romania and Bulgaria. The sub-sector food, beverages and tobacco are most important in Iceland and in the Netherlands.

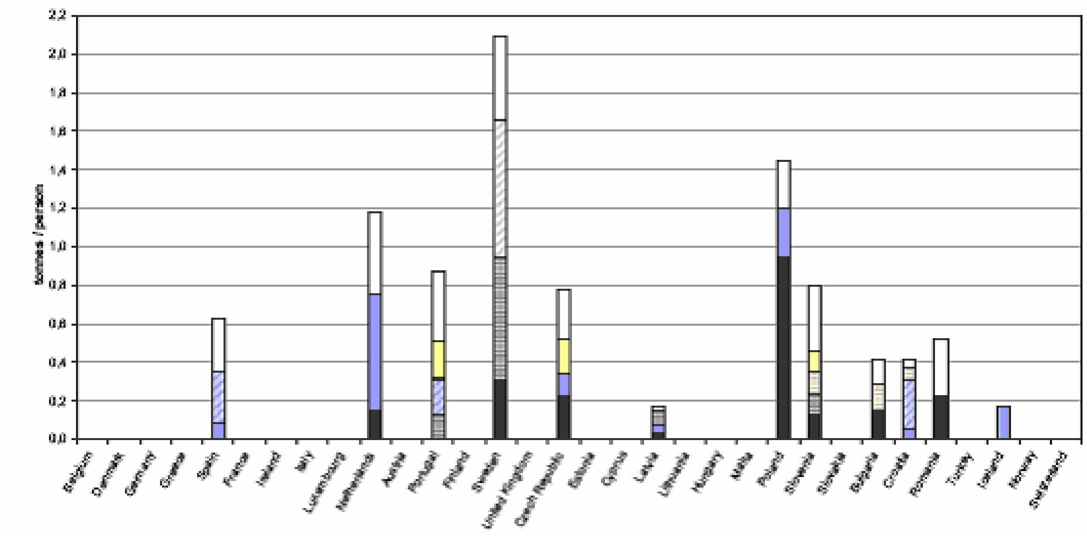


Figure 2.9 Waste generated by the manufacturing industry (15-37) by countries and sub-sectors for 2002 (tonnes/person)

Table 2.3 Sub-sectors

Sub-sector	*Division Code*
Food, beverages, tobacco industry	15-16
Textile industries	17-18
Leather industries	19
Wood and wood products	20
Paper and paper products	21
Printing and publishing	22
Refineries, etc.	23
Chemical industries	24
Rubber and plastics	25
Non-metallic mineral products	26
Basic metal industries	27
Fabricated metal products, machinery, electrical, optical and transport equipment	28-35
Other manufacturing industries	36-37

2.3 Properties of Solid Wastes

Physical, Chemical and Biological Properties can be quantified through calculations and data collection, and these properties must be known to develop and design a solid waste management system.

In the past, waste handlers needed to know little about the physical, chemical and biological properties of solid waste, because almost all of it was disposed in landfills. Today, however, proper solid waste management techniques involve recycling, reuse, tranformation, and highly regulated disposal, so more knowledge regarding the properties of MSW is necessary.

2.3.1 Physical Properties of Solid Wastes

Important physical properties of MSW include specific weight, moisture content, particle size distribution, field capacity, and hydraulic conductivity. Because MSW is a heterogeneous mass of constantly changing composition, these physical characteristics must be viewed on an aggregate and an individual-component basis (Shah, 2000).

Specific Weight: Specific weight is defined as the weight of a material per unit of volume (kg/m^3). Specific weight data are needed to get an idea of the total mass and volume of the waste that must be managed. Table 2.4 presents specific weights for a few typical categories of MSW.

Table 2.4 Typical uncompacted specific weights for municipal waste components

Components	***Specific Weight (kg/m^3)***
Broad Categories	
Paper, cardboard, plastics	80
Food wastes	297
Miscellaneous rubbish	160
Ash, dirt, brick, ferrous metal	475
Municipal solid waste	148
Specific Categories	
Plastic	65
Aluminum	160
Tin cans	89
Yard waste	101

Reduction in the volume of solid waste is an important consideration in collection, transport, and disposal. Volume reduction may be expressed in terms of a compaction ratio as well as a percentage. The performance of baling and compaction equipment is rated by the percentage of volume reduction and the compaction ratio as well.

Expressed as an equation:

Volume reduction (%) = $100(1-(V_f / V_i))$

V_i : initial volume of wastes before compaction (m^3)

V_f : final volume of wastes after compaction (m^3)

The compaction ratio = V_f / V_i

<u>Moisture Content:</u> The moisture content of solid waste is expressed in the wet weight method or the dry weight method of measurement. In the wet weight method, moisture is expressed as a percentage of the wet weight of the material. In the dry weight method, it is expressed as a percentage of the dry weight of the material.

In solid waste management, the wet weight method is most commonly used, expressed as an equation:

$m = [(w-d)/w] * 100$

m: moisture content (%)

w: initial weight of the sample as delivered (kg)

d: weight of the sample after drying at 105°C (kg)

Table 2.5 provides typical moisture contents of MSW components.

Table 2.5 Typical moisture content of municipal solid waste components

	Moisture Content (% by wt)	
Component	**Range**	**Typical**
Food wastes	50-80	70
Paper	4-10	6
Cardboard	4-8	5
Plastics	1-4	2
Textiles	6-15	10
Rubber	1-4	2
Leather	8-12	10
Garden trimmings	30-80	60
Wood	15-40	20
Glass	1-4	2
Tin cans	2-4	3
Nonferrous metals	2-4	2

Particle Size Distribution: The particle size and the size distribution of various component materials in solid waste are considered in biological transformation, recovery of materials, and incineration.

Effective size: $(l \times d)^{1/2}$

Waste components are usually described by lenght x breadth x height (l x b x h).

Field Capacity: The field capacity of solid waste is the total amount of moisture that a sample of that waste will hold freely against the downward pull of gravity. For solid waste in a landfill, the field capacity decreases with the overburden weight and can be estimated by using the following empirically derived equation:

$$FC = 0.6 - 0.55\ (W / 10{,}000 + W)$$

2.3.2. Chemical Properties of Solid Wastes

Solid waste can be separated into combustible and noncombustible materials, but if the solid waste is to be used as fuel, it is important to consider the following properties:

1. Proximate analysis
2. Ultimate analysis
3. Energy content

Proximate analysis: Proximate analysis is a chemical characteristic that determines the amount of surrogate parameters in place of the true chemical content. These parameters are normally moisture, volatile matter, fixed carbon, and ash.

Ultimate analysis: Ultimate analysis determines the percentage of each element in solid waste. The percentages of the five elements –Carbon, Hydrogen, Oxygen, Nitrogen, Sulfur-, moisture and ash for solid waste are 30%, 4%, 25.5%, 0.37%, 0.13%, 20%, 20% respectively. The results of ultimate analysis are used to characterize the chemical composition of organic matter in the waste.

Energy content: Energy content of the organic components in solid waste can be determined by using a boiler as a caloric meter, by calculation and by experimental determination using a bomb calorimeter test.

2.3.3. Biological Properties of Solid Wastes

The biological properties of municipal solid waste are relevant, because aerobic/anaerobic digestion is used to transform waste into both energy and beneficial end products. The relevant fractions for biological transformation include proteins, lipids, and carbohydrates.

Biodegradables: An important characteristic of the organic component in solid waste is that most of it can be biodegraded into gases and relatively inert and inorganic solids. The putrescible nature of organics has the potential of producing odors and attracting flies.

Biodegradability of the food fraction of solid waste is given by the equation:

BF= 0.83-0.028LC

Where BF is the biodegradable fraction expressed on a volatile solids basis, 0.83 and 0.028 are empirical constants, and LC is the lignin content of volatile solids (% of dry wt).

Nonbiodegradables: The remaining materials in solid waste are usually noncombustibles; glass, ceramics, dust, dirt, and metals. These usually account for 12 to 20 percent of the dry solids. They are the residues left after combustion.

2.4 Composition of Solid Wastes

2.4.1 Composition of Solid Wastes in USA

In 2003, U.S. residents, businesses, and institutions produced more than 236 million tons of MSW, which is approximately 4.5 pounds of waste per person per day (EPA, 2003).

Organic materials continue to be the largest components of MSW: Paper and paperboard products account for 35 percent of the waste stream, with yard trimmings and food scraps together accounting for about 24 percent. Plastics comprise 11 percent; metals make up 8 percent; and rubber, leather and textiles account for about 7 percent. Wood follows at 6 percent, and glass at 5 percent. A breakdown, by weight, of the MSW materials generated in 2003 is provided in Figure 2.10 (EPA, 2003).

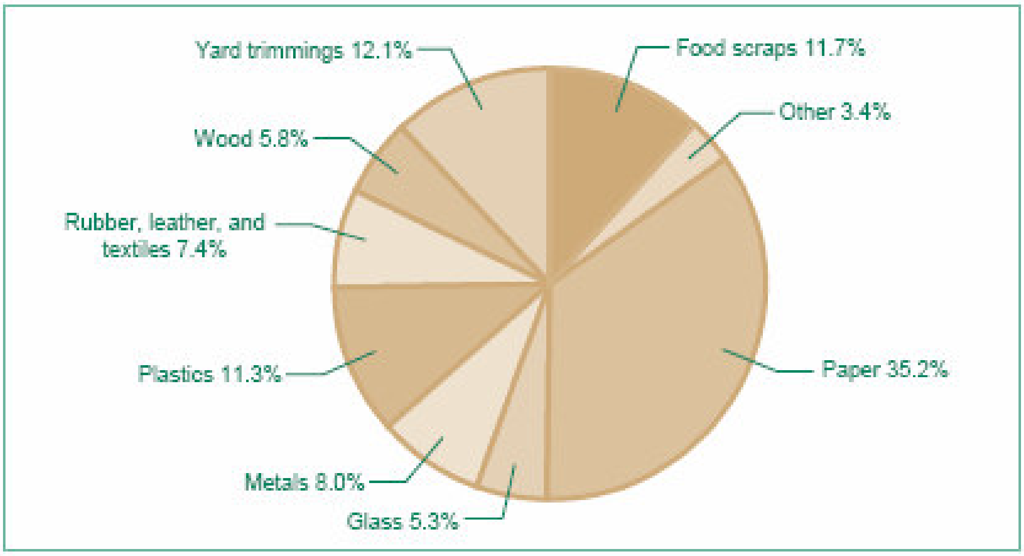


Figure 2.10 2003 total MSW generation in USA– 236 million tons (before recycling)

The breakdown, by weight, of product categories generated in 2003 is shown in Figure 2.11. Containers and packaging made up the largest portion of waste generated, about 75 million tons. The second-largest portion of MSW was nondurable goods, comprising just over 26 percent. Durable goods make up the third largest segment, accounting for almost 40 million tons (EPA, 2003).

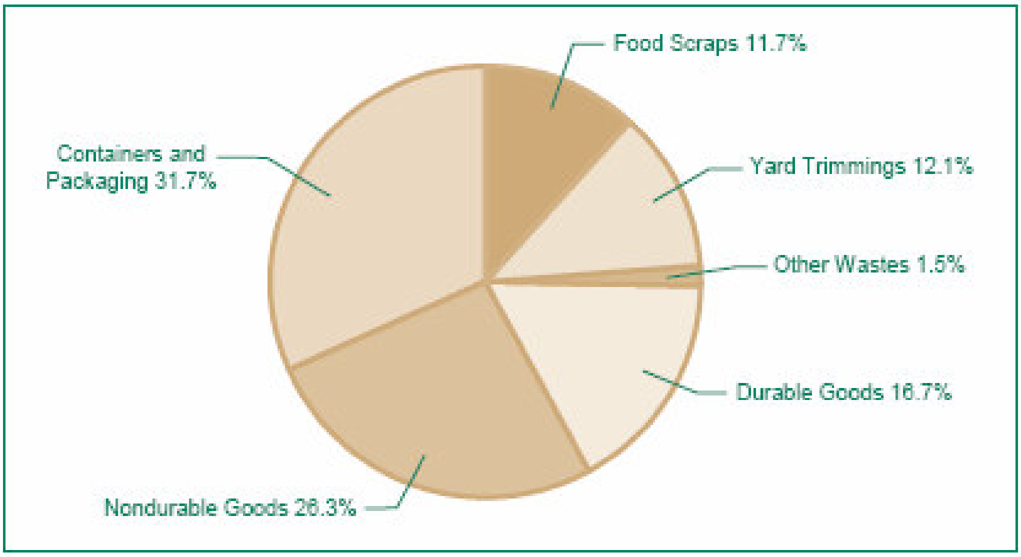


Figure 2.11 Products generated in MSW-2003 in USA (Total Weight = 236 million tons)

2.4.2 Composition of Solid Wastes in TURKEY

Per capita household solid waste generation in Turkey is 0,6 kg/day, whereas municipal solid waste generation is close to 1 kg/day. The major constituents of municipal solid waste are organic in nature and approximately 1/4 of municipal solid waste is recyclable. Municipal recovery operations conducted with more than 60 municipal authorities have proven a solid evidence of public acceptance and continuing support from the citizens. Opinion polls show that more than 80% of the population is ready and willing to participate in separate collection programs.

The State Institute of Statistics (SIS) published one of the major sources of information on HSW in Turkey in 1995 (latest data available for a comprehensive report). According to SIS, data covers 57% of municipalities nationwide and corresponds to a sufficiently long time frame and statistically acceptable waste collection frequencies.

MSW statistics were studied separately by SIS. These data show that majority of the household waste in Turkey is organic in nature and slag & ash constitutes an important fraction. Considering the fact that the data belong to a period when coal heating was the dominant method employed in most of the households in Turkey, slag & ash represents an important fraction. However, at least in major towns, natural gas has now become the major source of energy used for household heating. Therefore, one should expect recent changes in the household solid waste composition. Household solid waste compositions in Turkey are stated in Table 2.6 and treatment of solid waste is stated in Table 2.7 details.

Table 2.6 Household Solid Waste compositions in Turkey (SIS, 1995)

Season	*HSW (kg/day)*	*Organic&Wet*	*Ash&Slag*	*Recyclable*
Summer	0,60	80,21 %	2.61 %	17.18 %
Winter	0,50	46.20 %	45.89 %	7.90 %
Average	0,57	68.87 %	17.04 %	14.09 %

Table 2.7 Treatment of solid waste (SIS, 1995)

	1994	*2001*
% Landfill	4,7	15
% Composting	1,1	2,0

Although the 1995 SIS data in solid waste management presents the most comprehensive and statistically reliable solid waste data in Turkey, it is a fact that the past years may represent a significant change in the characteristics of solid waste. CEVKO (Environmental Protection and Packaging Waste Recovery & Recycling Trust) conducted a survey on municipal data for the cities of Bursa, Istanbul, Izmir, Adana and Mersin in 2000. A summary of the data is given in the table 2.8 below.

Table 2.8 Municipal Solid Waste Composition in Major Cities of Turkey (%, in weight) (ÇEVKO, 2000)

	BURSA	***ISTANBUL***	***IZMIR***	***ADANA***	***MERSIN***
Organic	53,1	43	46	64,4	63
Recyclable	36,4	33,9	31,0	25,2	29,4
Paper/board	18,4	7,8	12	14,8	18,42
Plastics	11,6	14,2	12	5,92	6,69
Metal	3	5,8	3	1,4	1,25
Glass	3,4	6,2	4	3,08	3,08
OTHERS	10,5	23,1	23	11,4	7,6

Table 2.9 Average Municipal Solid Waste Composition in Turkey (ÇEVKO, 2000)

	Large Cities	***Medium Towns***	***Small Towns & Villages***
Organic	45-50%	50-55%	60%
Recyclable	30-35%	20-25%	15%
Others	20-25%	25%	25%

Based on these evaluations and interpretation of the Municipal Solid Waste in Turkey, average per capita MSW production in Turkey is 0,97 kg/person-day. The composition of municipal solid waste, which can be seen is Table 2.9, can be taken as organic 50-55%, recyclable 20-25% and others (ash & slag, dust etc.) 20-25%.

2.4.3 Composition of Solid Wastes in EU

Approximately 740 millions tonnes of waste are generated by the manufacturing industry in Europe every year. The range of industrial wastes generated is as broad as the manufacturing industries that generate them, and as the waste management options used-which combine recycling, recovery and disposal techniques.

Manufacturing waste consists of food, wood, paper, chemical, non-metallic mineral, basic metal and other waste. A comparison of WE (Western Europe) and CEE (Central and Eastern Europe) countries shows that WE generates most food, wood, paper, non-metallic and other manufacturing waste.

The differences in the composition of manufacturing waste are probably influenced by the strong representation of paper industries in some reporting countries. CEE countries generate most manufacturing waste from chemical, iron and steel industries. In WE, no dominant industry can be identified, but in five reporting countries the food, wood and paper industry each accounted for about 20% in 1998.

A comparison of manufacturing waste generated in selected CEE countries from 1995 to 1998. (Figure 2.12) shows that the contribution to the generation of manufacturing waste increased from 50% to 59%.

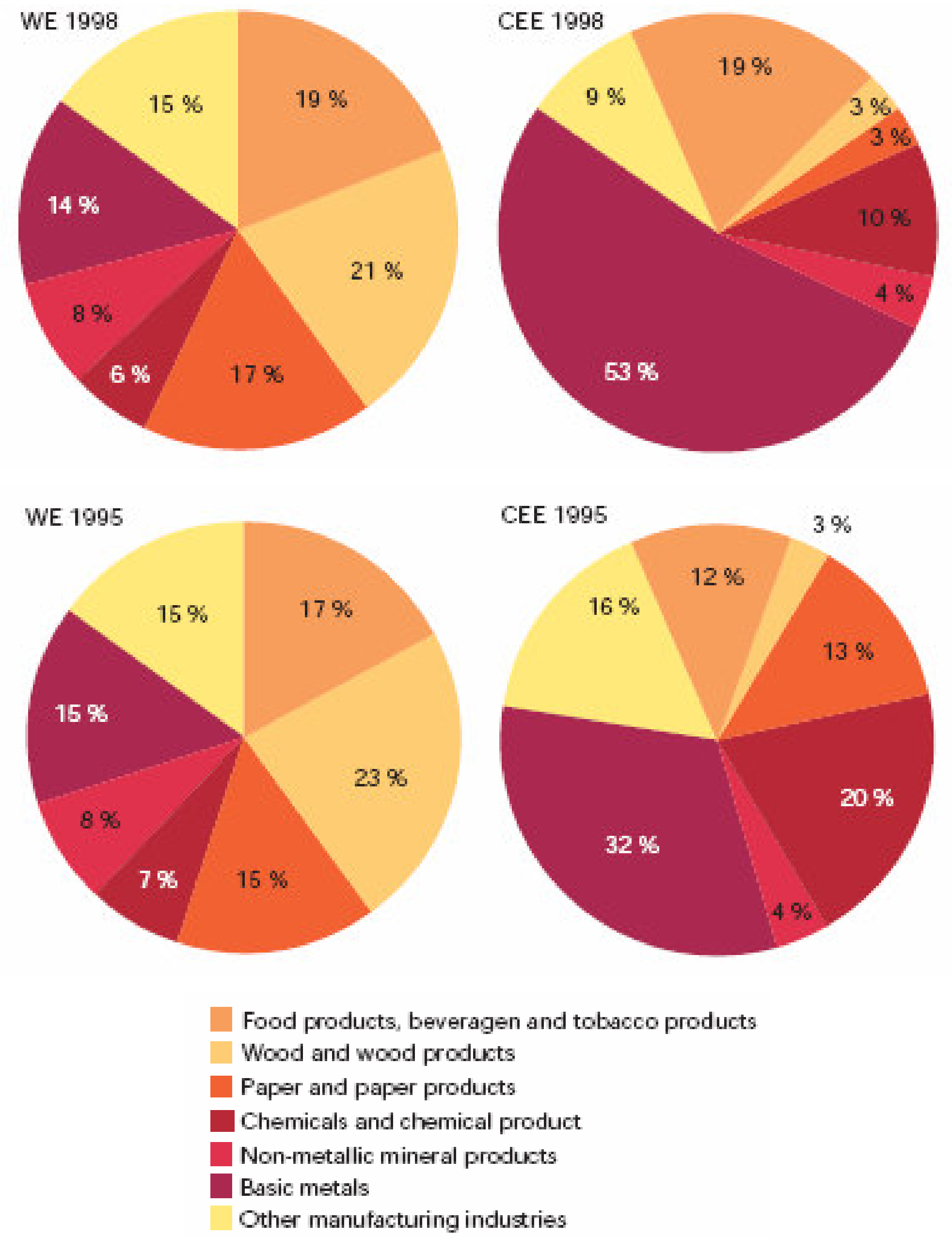


Figure 2.12 Manufacturing waste profiles in selected countries in western Europe and central and eastern Europe

CHAPTER THREE
INDUSTRIAL SOLID WASTE MANAGEMENT

3.1 Solid Waste Management Hierarchy

Any material that is thrown away or discarded as being useless or unwanted is considered to be solid waste. One of the pressing problems facing municipalities today is the efficient disposal of urban solid wastes on a long-term basis. Once a simple problem, the disposal of solid waste has become a complex dilemma for our modern and wasteful industrial society. More and more, these problems are in the news, discussed in public forums, and argued in courts. Frequently, technical and economic issues have taken a back seat to political and social concerns, and further complicating the problem is the ever-increasing amounts of solid waste being generated by our society and the cost of its processing and disposal. Because these disposal and processing systems are unpopular with the general public, obtaining new sites has become very difficult and costly. Pollution abatement efforts often result in the closing of landfills and public resistance to new landfills or incinerators.

In the U.S. Resource Conservation and Recovery Act (RCRA) of 1976, solid waste is defined as ‘garbage, refuse, sludge from a wastewater treatment plants, water supply treatment plant, or air pollution control facility, and other discarded material including solid, liquid, semisolid, or contained gaseous material resulting from industrial, commercial, mining, and agricultural operations, and from community activities’. Solid waste does not include solid or dissolved materials in irrigation return flows or industrial discharges (Shen, 1995).

Management can be defined as the carefully planned, judicious use of means to achieve an end. In this case, an ‘end’ is the removal and disposal of unwanted material. To achieve this, technical, environmental, administrative, economic, and political problems must be solved. The effort to address these problems is usually referred to as the practice of solid waste management. It encompasses the planning, design, financing, construction, and operation of facilities fot the collection, transportation, processing, recycling, and final disposal of residual solid waste materials. All this is based on sound principles of public health, engineering, economics, aesthetics, conservation, and environmental considerations, along with social and ethical issues.

An indication of how and where solid wastes are generated in our technological society is shown in the simplified materials flow diagram presented in Fig. 3-1. Solid wastes are generated at the start of the process, beginning with the mining of raw materials (Tcobanoglous, Theisen & Vigil, 1993).

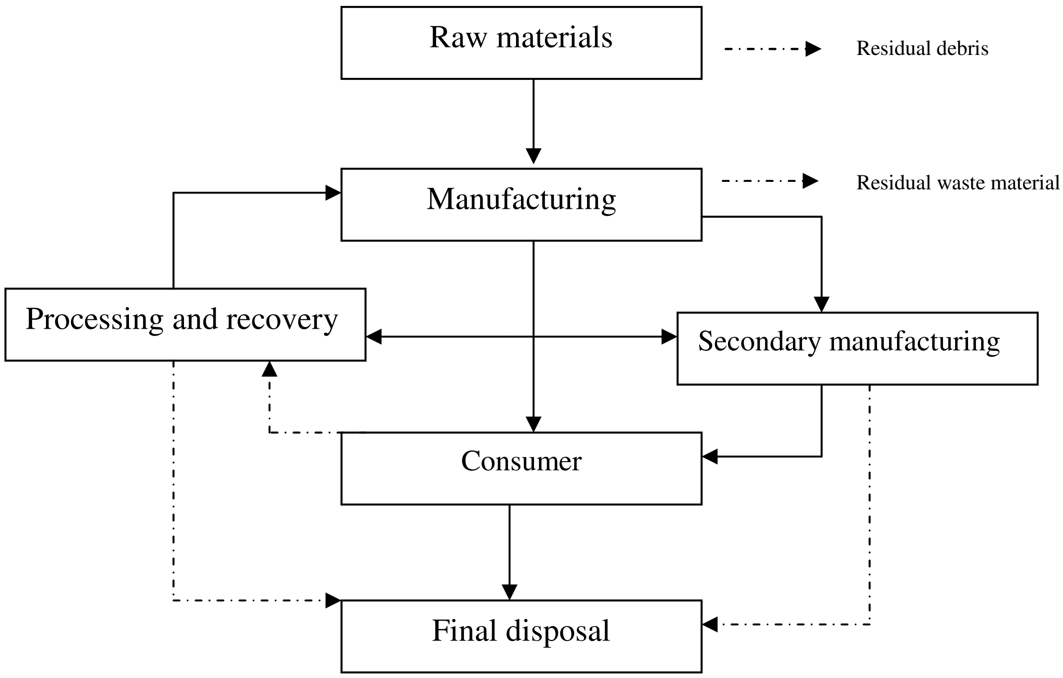


Figure 3.1 Solid Waste Generation

3.2 Key Components of Solid Waste Management

Solid waste management is the generation, separation, collection, transfer, transportation and disposal of waste in a way that takes into account different parameters, such as public health, economics, environment, conservation aesthetics and is responsive to public demands.

Solid waste management can be divided into six key components:

1. waste generation
2. waste handling and separation, storage, and processing at the source
3. collection
4. separation and processing and transformation of solid wastes
5. transfer and transport
6. disposal

In the Figure 3.2 general steps of solid waste management are indicated:

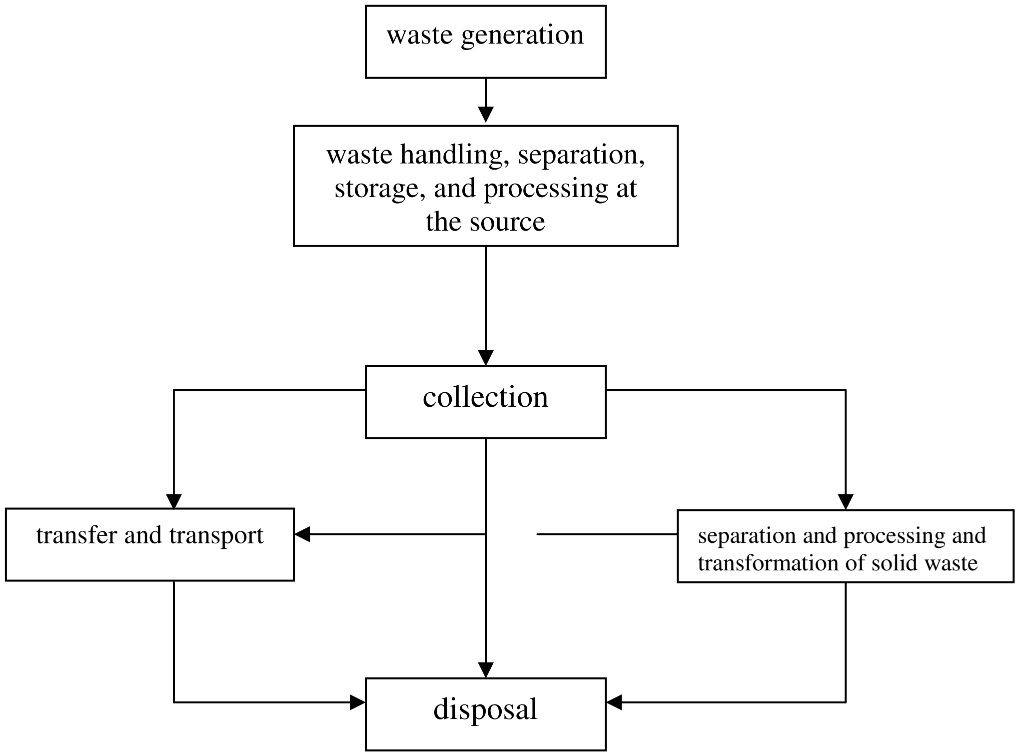


Figure 3.2 Solid Waste Management

Waste Generation: Waste generation encompasses activities in which materials are identified as no longer being of value and are either thrown away or gathered together for disposal. It is important in waste generation to note that there is an identification step and that this step varies with each individual waste.

Waste generation is, at present, an activity that is not very controllable. In the future, however, more control will be exercised over the generation of wastes. In states where waste diversion goals are set by law, and must be met under threat of economic penalty, it is necessary to put in place a manifest system to monitor waste diversion. Source reduction, although not controlled by solid waste managers, is now included in system evaluations as a method of limiting the quantity of waste generated (Tcobanoglous, Theisen & Vigil, 1993).

<u>Waste Handling and Separation, Storage, and Processing at the source</u>: Waste handling and separation involves the activities associated with management of wastes until they are placed in storage containers for collection. Handling also encompasses the movement of loaded containers to the point of collection. Separation of waste components is an important step in the handling and storage of solid waste at the source.

On-site storage is of primary importance because of public health concerns and aesthetic considerations.

<u>Collection</u>: The functional element of collection includes not only the gathering of solid wastes and recyclable materials, but also the transport of these materials, after collection, to the collection vehicle is emptied. This location may be a materials processing facility, a transfer station, or a landfill disposal site. In small cities, where final disposal sites are nearby, the hauling of wastes is not a serious problem. In large cities, however, where the haul distance to the point of disposal is often greater than 24 km, the haul may have significant economic implications. Typcially, collection is provided under various management arrangements, ranging from municipal services to franchised private services conducted under various forms of contracts. In several parts of the country, large solid waste disposal companies, with conracts in many cities, own and operate collection vehicles and landfill disposal sites. Collection services for industries vary widely. Some industrial wastes are handled like residential wastes; some companies have disposal sites on their own properties that use conveyor belts or water slurry transport. The latter is used for mineral wastes and agricultural wastes in many cases. Each industry requires an individual solution to its waste problems.

Separation, Processing and Transformation of Solid Waste: The recovery of separated materials, the separation and processing of solid waste components, and transformation of solid waste that occurs primarily in locations away from the source of waste generation are encompassed by this functional element. The types of means and facilities that are now used for the recovery of waste materials that have been separated at the source include curbside collection, drop off, and buy back centers. The separation and processing of wastes that have been separated at the source and the separation of commingled wastes usually ocuur at a materials recovery facility, transfer stations, combustion facilities, and disposal sites.

Processing often includes the separation of bulky items, separation of waste components by size using screens, manual separation of waste components,size reduction by shredding, separation of ferrous metals using magnets, volume reduction by compaction, and combustion.

Transformation processes are used to reduce the volume and weight of waste requiring disposal and to recover conversion products and energy. The organic fraction of municipal solid waste can be transformed by a variety of chemical and biological processes. The most commonly used chemical transformation process is combustion, which is used in conjunction with the recovery of energy in the form of heat. The most commonly used biological transformation process is aerobic composting. The selection of a given set of processes will depend on the waste management objectives to be achieved.

Transfer and Transport: The functional element of transfer and transport involves two steps: (1) the transfer of wastes from the smaller collection vehicle to the larger transport equipment and (2) the subsequent transport of the wastes, usually over long distances, to a processing or disposal site. The transfer usually takes place at a transfer station. Although motor vehicle transport is most common, rail cars and barges are also used to transport wastes.

Disposal: The final functional element in the solid waste management system is disposal. Today the disposal of wastes by landfilling or landspreading is the ultimate fate of all solid wastes, whether they are residential wastes collected and transported directly to a landfill site, residual materials from materials recovery facilities (MRFs), residue from the combustion of solid waste, compost, or other substances from various solid waste-processing facilities.

In most cities, planning for waste disposal involves dealing with city, county, or other regional planning commissions and agencies. Thus, land-use planning becomes a primary determinant in the selection, desing, and operation of processing facilities and landfills. Environmental impact statements are required for all new landfill sites to ensure compliance with public health, aesthetics, and future use of land.

3.3 Recycling

3.3.1 Paper and Paperboard Recycling

Recycled paper is generated for instance in private homes, offices, industries and public institutions. Paper from private homes consists typically of newspaper, magazines and junk mail. Industries and businesses often generate large amounts of used packaging materials especially cardboard. Printing and copy paper is generated in offices and other institutions and the paper refining industry also generate waste paper of different sorts. The consumption of paper per capita typically depends upon the industrial and economical level of development of the society, as is the case with the general waste generation rate. Highly developed countries like Europe, Japan and USA have paper consumption rates that are many times higher than countries in Africa, South America or Southeast Asia (Figure 3.3). USA is the number one paper consumer in the world based on the per capita consumption rate and therefore also one of the major waste paper producers in the world.

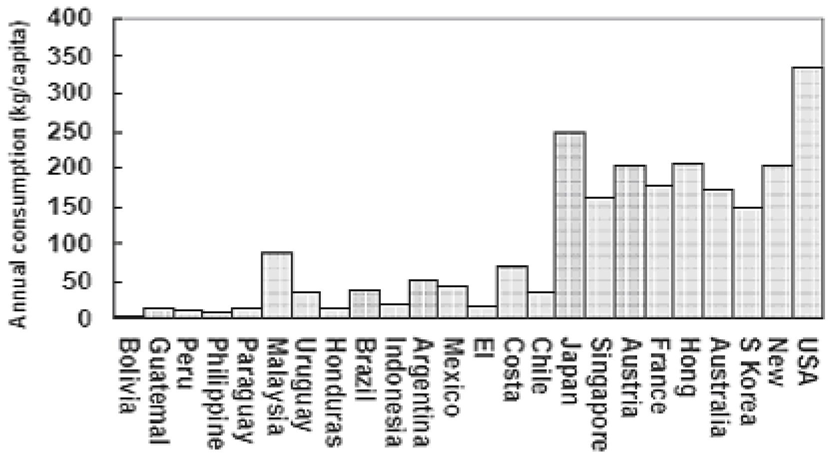


Figure 3.3 Annual consumption of paper in selected countries around the world.

Recycled wastepaper has long been used as a source of fiber to augment pulp made from virgin materials. Depending on the application, various fractions of recycled and virgin materials can be incorporated all the way up to 100 percent recycled. Each recycling of wastepaper, however, results in losses so it is not possible to use the same fiber over and over again. Each time paper is soaked in water, heated, and processed, some of cellulose breaks down into starches and is lost; also, in each processing some of the smaller fibers do not bond together and are lost as well. Not only is less fiber made available after each recycling, but the fibers are shorter and the resulting product is not as strong as product made from virgin materials. Nonetheless, there are abundant uses for reycled wastepaper (Masters, 1998).

Recycled wastepaper is also used to make various construction products such as cellulose insulation, fiberboard, and some flooring materials. Other applications include animal bedding, nursery pots, garden mulch, and trays.

Most of the recycled paper is consumed in Europe, North America and Asia (Figure 3.4). These regions consume more than 90% of the total quantity of recycled paper generated in the world. They are also the regions generating most of the world’s waste paper. The use of recycled paper is increasing rapidly (Figure 3.4).

Predictions for 2005 indicate that the global recycled paper consumption will exceed 400 million tons. This is 30% more than in 1995.

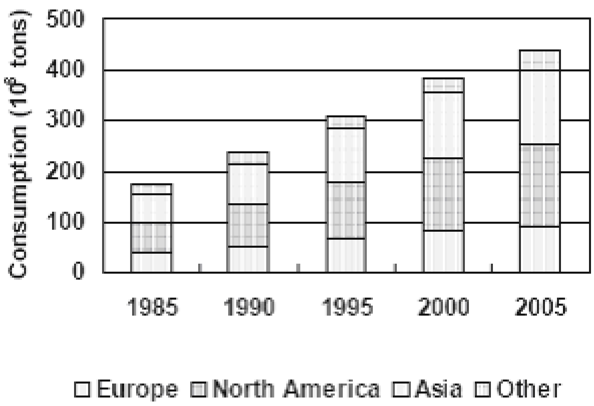


Figure 3.4 Consumption of recycled paper by region

3.3.2 Recycling Plastics

The Plastic Bottle Institute of the Society of the Plastics Industry has developed a voluntary coding system for plastic bottles and other rigid containers that uses the familiar three arrows in a triangle, this time with a numerical designation that indicates the type of resin used in the plastic. Table 3.1 describes the labeling system and high-lights the main uses of the designated plastics (Masters, 1998).

PET and HDPE together account for 79 percent of all plastics recovered from the waste stream, with most of that being milk jugs and clear plastic soda bottles. PET provides a better barrier to transmission of gases than HDPE, which makes it a better container for carbonated beverages and other foods whose aromas need to be contained. PET also fetches a much higher price in the recycling market.

When plastics are recycled, it is often important to separate them carefully by resin type and color. Different resins have different melting points, so if a batch of mixed plastics is being heated and reformed into new products some resins may not melt at all and some may end up burning. A single PVC bottle in a batch of 20.000 PET bottles, for example, can ruin the whole batch and potentially damage the manufacturing equipment. Similarly, if polypropylene, which is difficult to distinguish from polyethylene, contaminates a batch of recycled polyethylene, the resulting blend would be useless. Plastic recycling is also complicated by the potential for contamination by the products that they once contained. Plastics do absorb, to varying degrees, materials that they come in contact with. Substances such as pesticides and various oils will migrate slowly into their plastic containers, and some will survive the melting and reforming processes when recycled (Masters, 1998).

Recycled plastics find application in a number of products. Recycled PET bottles, for example, are being transformed into quality fibers for jackets and other outdoor clothing, as well as fiberfill material for cushions. Recycled PET is also used to make carpeting, surfboards, sailboat hulls, as well as new PET soft-drink bottles. To avoid the contamination problem mentioned previously, recovered PET used in new soft-drink bottles is usually sandwiched between an inner and outer layer of virgin plastic. HDPE and LDPE are often recycled into new detergent bottles, trash cans, and drainage pipes. For some of the most popular uses for recycled HDPE and LDPE, minor color variations in the final product are not particularly important. For other products, such as colored detergent bottles, variations in color would affect consumer perceptions of the product, so presorting of recyclables by color can be important.

Table 3.1 Plastics coding system - USA

Designation		Polymer	Applications	Generation (1000 tonnes/yr)	Recovery (%)
1	PETE	Polyethylene terepthalate (PET)	Soft drink bottles, peanut butter jars; frequently recycled	890	26
2	HDPE	High-density polyethylene	Milk, water, juice, detergent, motor oil bottles; often recycled	3750	6
3	V	Vinyl-polyvinyl chloride (PVC)	Cooking oil bottles, credit cards, household food wrap, building materials; rarely recycled, toxic if burned	1120	0
4	LDPE	Low-density polyethylene	Shrink wrap, garbage and shopping bags, lids, cups; rarely recycled	5660	0.1
5	PP	Polypropylene	Snack food wrap, margarine tubs, straws, car batteries; occasionally recycled	1540	6
6	PS	Polystyrene	Pharmaceutical bottles, Styrofoam cups, clear salad bowl lids, packing peanuts; rarely recycled	2250	0.1
7	Other resins		Multilayered, mixed-material containers, squeezable bottles; rarely recycled	2340	0.1
	Totals			17.500	3.5

3.3.3 Glass Container Recycling

Recovered glass that will be remade into new container glass need to be separated by color: clear (flint), green (emerald), or brown (amber). Those colors have traditionally been created with permanent dyes, but there are now colored polymer coatings that can be applied to the outside of clear glass containers. If these coatings would allow all glass used in containers to be clear, the need to separate by color as well as the need to use care to prevent bottle breakage during collection would be eliminated. An additional advantage of the polymer coatings is that they make the container considerably strongeri which could allow bottles to be made even lighter than they are now.

Once recovered glass has been separated by color and the metal rings and caps removed, it needs to be crushed into smaller pieces, called cullet. When significant quantities of color-separated cullet are accumulated, they are usually shipped to container manufacturers to be remade into new glass bottles and jars. Glass has the unusual property of being 100 percent recyclable; that is, the same bottle can be melted down and remade over and over again without any product degradation. Moreover, cullet melts at lower temperature than the raw materials from which new glass is made (silica sand, soda ash, and limestone), which helps save energy (Salvato, Nemerow & Agardy, 2003).

Glass recycling process is a widely used technique in European countries. In the table 3.2 below the glass recycling ratios in these countries can be observed.

Table 3.2 Glass recycling rates in Europe

Country	*Tonnes Collected*	*Recycling Rate (%)*
Austria	203.000	76
Belgium	235.000	67
Denmark	108.000	67
Finland	28.000	50
France	1.300.000	48
Germany	2.763.000	75
Greece	37.000	29
Ireland	28.000	31
Italy	890.000	54
Netherlands	367.000	77
Norway	36.000	72
Portugal	71.000	32
Spain	371.000	31
Sweden	95.000	56
Switzerland	242.000	84
Turkey	54.000	22
UK	492.000	28
Total	7.320.000	

3.3.4 Aluminum Recycling

By most measures, the most valuable collectable in a municipal recycling program is aluminum cans. A tonne of aluminum is typically worth 10 times as much as a tonne of PET or HDPE, and it generates on the order of 20 times as much revenue per tonne as glass, steel cans, or newspapers. Even though it may comprise only 2 or 3 percent of the total tonnage of collected recyclables, it often generates on the order of 20 to 40 percent of the total revenues (Rhyner, Schwartz, Wenger & Kohrell, 1995).

Recycling aluminum not only helps reduce the demands placed on landfills, but doing so saves large amounts of energy as well. The production of new aluminum begins with the mining of bauxite ore. Then, using a procedure known as the Bayer process, impurities are removed and the aluminum hydrates and hydroxides in bauxite are converted to aluminum oxide, or alumina. Alumina is then electrolytically reduced to aluminum metal. That electrolysis, known as the Hall-Heroult process, consumes enormous amounts of electricity. On the average, the two-step conversion of bauxite to aluminum metal requires 15 kWh of electricity plus 60.000 kJ of fossil fuel energy per kilogram of metal produced.

The recycle aluminum, the scrap is melted down is a furnace, mixed with various alloys and primary aluminum as needed, and then cast into ingots. The process requires 0.08 kWh of electricity and 4200 kJ of fossil fuel per kilogram of aluminum produced. Thus, recycling saves roughly 99 percent of the electricity and 93 percent of the fossil fuel energy compared with primary aluminum production.

3.3.5 Other Metals

Metals can be conveniently classified into two categories: ferrous and nonferrous. Nonferrous metals (e.g., aluminum, copper, lead, zinc) have little or no iron in them, while ferrous metals do. In keeping with the EPA definitions, the only metals we will consider here are those that end up in the municipal solid waste stream as discarded refrigerators, stoves, water heaters, and so forth. That excludes, for example, preconsumer scrap that is recovered during metal manufacturing, and it also excludes old automobile and truck bodies that are crushed and recycled.

Recovery of ferrous metals in white goods (appliances) was estimated to be 68 percent; 48 percent of the steel food and beverage cans were recycled; and 35 percent of the aluminum was recovered. The recovery rate of ‘other nonferrous’ metals is quite high, averaging 63 percent. That category is dominated by lead, most of which is in car batteries, with 95 percent of that battery lead being recovered (Masters, 1998).

3.3.6 Materials Recovery Facilities

Recyclable materials need to be sorted to separate the glass, plastics, newspapers, cans, and so forth. If a community has a recycling system in place, some of this separation is usually done by consumers, some may be done by the crew of the recycling truck as they make their pick-ups, and some is typically done at a *materials recovery facility* (MRF).

The primary function of a materials recovery facility is to separate bottles by color, plastics by resin, cans by their metal content, as well as old newspapers (ONP), old corrugated containers (OCC), and compostable organics. The second function is to densify those separated materials so that they can be more easily shipped to end users. Densification includes crushing bottles, flattening metal cans, granulating and baling plastics, and baling waste paper.

3.3.7 Processing Equipment for Commingled Wastes

Many communities collect commingled recyclables and mixed wastes. Such wastes could be landfilled as collected, but they contain valuable resources that should be recovered. Not only can recyclables be removed, but combustible products can be prepared for waste-to-energy incineration, and materials to be landfilled can be densified to take up less space. Processing facilities that handle such mixtures may utilize a combination of large, heavy-duty machines to screen, shred, separate, and classify the waste (Masters, 1998).

Raw solid waste consists of a mix of boxes, bags, newspapers, chunks of wood, bottles, cans, garden clippings, tires, and so forth, with varying sizes and shapes. To facilitate recovery of various components of the waste, it must be broken down into smaller pieces. A combination of machines that screen and shred the waste accomplishes this task.

3.3.7.1 Screening

The most common screen is a large-diameter, tilted, rotating drum with appropriately sized holes, called a trommel. These drums have a diameter of roughly 1 to 3 m, and the holes are often about 10 cm across-big enough to let most of the metal and glass fall through, but to small to pass much of the paper and larger objects. A sketch of a trommel is shown in Figure 3.5.

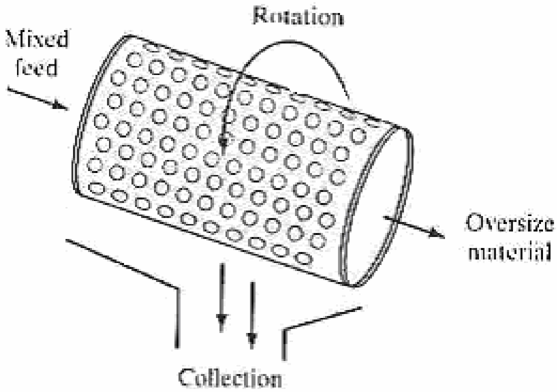


Figure 3.5 Screening

3.3.7.2 Shredding

Shredders are brute-force machines that pound, crush, pulverize, and shred the wastes. A number of types of shredders are available, but the one most commonly used in recycling operations is the horizontal axis hammermill shown in Figure 3.6.

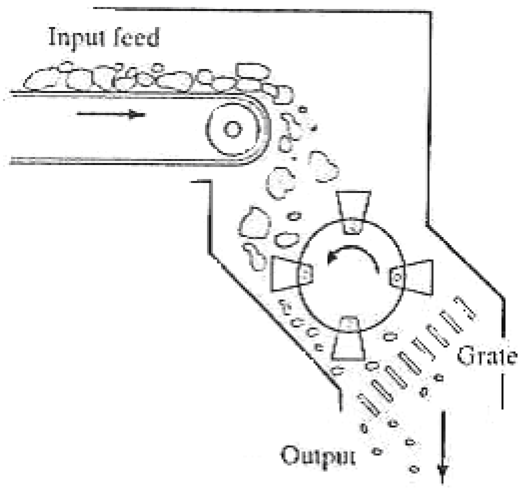


Figure 3.6 Shredding

Other types of shredders include flail mills, which are similar to hammermills except that the hammers are more like knives and there are no grates so materials make only one pass by the hammers. There are also knife shredders, which slice up objects like rags and bottles; shear shredders, with counterrotating blades that cut materials into strips; and pulverizers, which crush glass.

3.3.7.3 Magnetic Separators

After materials have been broken into small enough particles, they can be passed by magnets to remove ferrous metals. A number of design variations are possible, but they are all similar in nature. Ferrous metals are picked up by the magnet and moved away from the remaining materials on the main conveyor belt. Figure 3.7 shows one version of a magnetic separator.

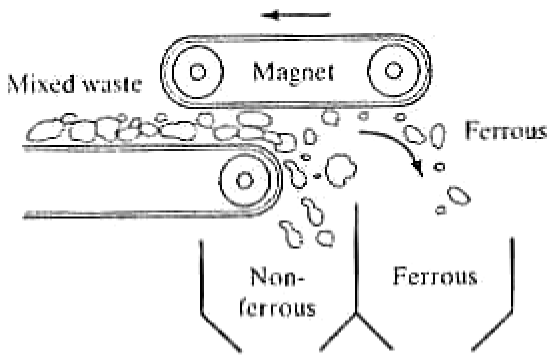


Figure 3.7 Magnetic Separator

3.3.7.4 Air Classification

Once the waste stream has been reduced to relatively small particle sizes, a blast of air, along with gravity, can be used to separate heavy particles from light ones. In one version of an air classifier, called an air knife, light particles such as plastic and paper are blown over barriers that separate a number of collection bins. Heavy particles are not affected much by the air stream, so they fall into the first hopper. The air knife shown in Figure 3.8 has two receiving bins, but more are possible if more sensitive separation is needed.

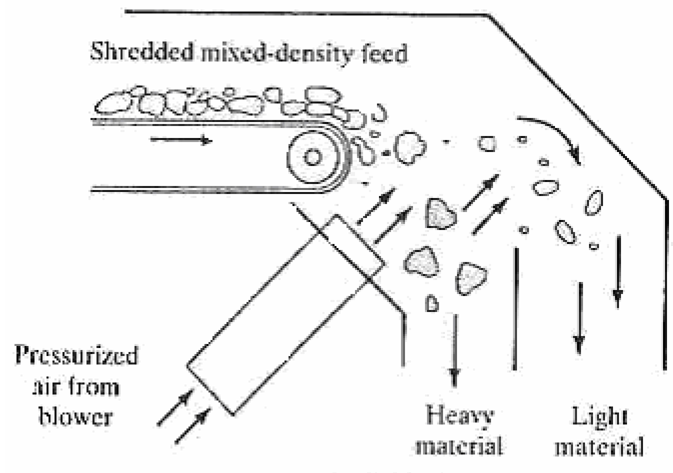


Figure 3.8 Air Classification

3.4 Solid Waste Management Practices in Turkey

Solid waste management involves items such as collection, transport, disposal, treatment, land filling, recovery, recycling and incineration. Common solid waste management practices in Turkey are:

Collection: Municipal solid waste is mostly collected from the households using metallic bins and containers. Typical sizes are 400 L and 800 L. Large cities generally use 800 L containers whereas 400 L containers are typical of small towns. The local municipalities usually supply these containers and bins, and the residents are required to put their solid waste into these bins within a plastic waste bag that is available in the market.

Transport: Collection and transport of solid waste, by law, is the responsibility of the Municipalities. Municipal trucks equipped with a hydraulic press are commonly used to transport the household solid waste.

Although these trucks can be equipped with 6, 7, 11, 13, 16, and 20 m^3 waste containment capacity; 7, 11 and 16 m3 capacities are quite standard around the country. However, there are several small villages, or even tourist sites, where the solid waste is transported by open trucks.

Disposal: Solid waste disposal methods are a major public concern in Turkey. Majority of the municipal solid waste disposal sites are still open dumps. Currently, only 7 sanitary landfills are used to dispose municipal solid waste and an additional 12 landfills are in the construction stage. Although the numbers represent a very small fraction of Municipalities, they correspond to almost 20% of municipal solid waste being land filled. Several other municipal landfills are in the project or bidding phase. Therefore, within the next ten years, more than 50 % of municipal solid waste in Turkey is expected to be land filled.

3.5 Solid Waste Recovery and Recycling in Turkey

Solid waste recovery and recycling has been a long-standing commercial activity in Turkey. Glass and paper recycling has been conducted at an industrial scale since the 1950's. With the recent investments of the industry in the recycling field, almost all types of plastic materials, glass, paper and metals can be recycled at industrial level. Turkey, one of the biggest steel scrap importers of the world, recycles more than 2 million tons of steel scrap annually. Recycling of nonferrous metals is widespread as well and conducted at industrial scale for aluminum, copper, lead and silver.

Recovery of municipal solid waste is mostly through the scrap dealers and individual collectors working on the streets and waste dumps. They collect and provide the raw material for the recycling industry. Recent data (2000) on the amounts of packaging waste being recovered and recycled with this system is given in the Table 3.3:

Table 3.3 Amounts of Packaging Waste (tons/year) Recovered and Recycled in Turkey (ÇEVKO, 2000)

	Market Figures (tons)	Amount Recovered (tons)	% Recycling
Paper & Board	1.850.000	700.000	36%
Glass	350.000	80.000	25%
Plastics	550.000	170.000	30%
Metal	150.000	50.000	30%
Total	2.900.000	1.000.000	35%

A strong demand exists for almost all types of packaging waste in Turkey, regardless of its materials nature. However, glass, paper and PET recycling are conducted at fairly high industrial capacities.

Paper and board is collected through the scrap/waste dealers and delivered to recycling facilities nationwide. There are more than 30 medium to large-scale paper recyclers in Turkey. Major outcome of these facilities is the packaging cardboard made of recycled paper.

Glass recycling is based on the market managed by the Glassworks Co. of Turkey, Sisecam, Inc. Company is a monopoly, which consumes more than 90% of the collected used glass bottles nationwide. Collection and recovery scheme is basically the same as paper and board recovery. Private entrepreneurs and scrap dealers collect and sort the used packaging material to be shipped to recycling plants. There are five major collection and glass cullet preparation units.

PET recycling has been an industrial activity since the establishment of a major PET recycling plant. Currently one large and two medium-scale PET recycling plants exist in Turkey, with the total operating capacity of more than 20,000 tons per annum. HDPE, LDPE recycling has also been a long-standing operation and resulted from the oil crises in the 1970's. Several small-scale plastic recyclers exist, since these facilities can be established with fairly low initial investments. PVC recycling is also similar to PE recycling operations.

3.5.1 Separate Collection of Household Packaging Waste

Separate/Curbside collection of the recyclable materials has been a fairly recent issue in Turkey. Several related pilot programs were implemented in the last 10 years. Currently more than 60 municipal recovery programs are in operation.

Public awareness and participation has been a concern in these programs, and therefore has been the subject of various analyses. A good example of such comprehensive programs was implemented by a joint effort of UNDP-CEVKO-local municipalities in the earthquake-affected regions of Turkey. This program covered 39,000 prefabricated settlements and about 130,000 people were directly affected by the earthquake, after which the solid waste management has been a serious problem. Results show that even under difficult living conditions, the public supports and participates in environmental actions.

Collection scheme is similar in all listed programs; i.e. weekly collection by plastic bags. Collected waste materials include plastic, glass, metal, and paper. Collected packaging waste is either transported to material recovery facilities or handled by the private waste contractors.

In the following table a list of municipal recovery programs implemented in Turkey is given Table 3.4:

Table 3.4 List of Separate Collection and MSW Recovery Programs in Turkey (Operated in cooperation with ÇEVKO and local municipalities) (ÇEVKO, 2002)

PROJECT REGION	No. of Municipalities	Start Date	No. of Households	No. of Hotels	No. of Schools	No. of Commercial Facilities	Data Frequency	Average Collection (kg/month)
Bakirkoy – ISTANBUL	5	1993	35.850		51	19	Weekly	62.000
BURSA	4	1995	62.230		65		Weekly	130.500
ESKISEHIR	2	1996	11.500		13		Weekly	15.000
Marmaris – MUGLA	1	1997	-	70	5	65	Monthly	435.000
Kusadasi – IZMIR	1	1998	1.072	140	10	45	Monthly	95.000
Konak – IZMIR	1	1999	3.957				Weekly	4.500
CANAKKALE	1	1999	2.550				Weekly	13.500
Soke - AYDIN	1	1999	900				Weekly	2.000
Etimesgut - ANKARA	1	1999	8.000				Monthly	15.000
Bandirma – BALIKESIR	1	2000	8.285				Weekly	13.500
Kadikoy – ISTANBUL	1	2000	14.000		40	50	Monthly	152.000
YALOVA	1	2000	5.314		11		Weekly	7.000
DUZCE	1	2000	5.348		12		Weekly	15.500
ADAPAZARI	1	2000	7.905		5		Weekly	19.000
Spacially Protected Areas	7	2000	11.400	110	15		Monthly	66.000
MimarSinan – ISTANBUL	1	2000	5.000		5		Weekly	27.000
MUGLA	1	2001	3.000		5		Monthly	17.500
TOTAL	31		186.311	320	237	179		1.090.000

Data is also collected on the material recovery facilities:

Table 3.5 Composition of Recyclable Materials Collected (ÇEVKO, 2000)

	Bakırköy	Beşiktaş	Kadıköy	Marmaris	Bursa
Source of Municipal Collection	Residential	Residential	Commercial	Touristic (Hotels)	Residential + Commercial
Period of data	3 years	2 years	2 years	3 years	3 years
Data Collection Frequency	Weekly	Weekly	Monthly	Monthly	Weekly
Paper & Board	38%	52%	74%	37%	70%
Glass	32%	24%	-	25%	9%
Metal	9%	6%	2%	5%	3%
Plastic	21%	18%	24%	33%	18%

3.6 Recyclable Materials Recovered from Solid Wastes

Common Recyclable Materials

Paper

High-Grade Paper

High-grade paper is usually generated in office environments and can earn recycling revenues when present in sufficient quantity. Types of high-grade paper include:

- Computer paper (also known as Computer Print Out or CPO). Can be all white or have a white main fiber with bright green or blue bars.

- White ledger. Most white office paper, including white computer paper, copy machine paper, letterhead, white notebook paper, and white envelopes. Common contaminants include glossy paper, wax-coated paper, latex adhesive labels, envelopes with plastic windows, and carbon paper.

- Tab cards. Usually manilla-colored computer cards; may be other colors but must be separated by color to be valuable as a high-grade paper (EPA, 2000).

Other Papers

These papers are less valuable than high-grade paper in terms of recycling, although they still can be cost-effective to recycle in many cases, Examples of other types of paper include: Colored ledger, Most non-white office paper, including carbonless paper, file folders; tablet paper, colored envelopes, and yellow legal paper, Corrugated Cardboard (also known as Old Corrugated Cardboard or OCC), Includes unbleached, unwaxed paper with a ruffled (corrugated) inner liner. It usually does not include linerboard or pressboard, such as cereal boxes and shoeboxes, for most businesses; cardboard is a cost-effective material to recycle.

Newspaper (also known as Old News Print or ONP). It is most valued when separated from other paper types, but can be recycled as mixed waste paper.

Miscellaneous waste paper. Encompasses most types of clean and dry paper which do not fall into the categories mentioned above, including glossy papers, magazines, catalogs, telephone books, cards, laser-printed white ledger, windowed envelopes, paper with adhesive labels, paper bags, wrapping paper, packing paper, sticky-backed notes, and glossy advertising paper, This mixed paper has limited value in existing markets.

Mixed waste paper. Paper that is unsegregated by color, quantity, or grade (e.g., combination of white ledger, newsprint, colored paper, envelopes without windows, computer paper, glossy paper, etc). Mixed paper generally sells below the price of the least valuable paper in the mix.

<u>Glass</u>

Color-separated

This includes all container glass that is separated into clear, green, and brown. When this glass is broken or crushed for recycling, it is called “flint,” “green,” and “amber” cullet, respectively.

Mixed Color

This is the same as color-separated glass except clear, green, and brown glass are mixed together. It generally has very limited market value.

<u>Plastic</u>

There are 7 types of plastic which are identified by a Society of Plastics Industry (SPI) code number ranging from 1 to 7. These numbers are usually found on the bottom of plastic containers inside a three-arrow recycling symbol. A description of each kind of plastic is presented below.

PET (SPI=1)

Polyethylene terephthalate (PET) is the most readily recyclable material at this time. It includes 1-and 2-liter clear soda bottles, as well as some bottles containing liquor, liquid cleaners, detergents, and antacids.

HDPE (SPI=2)

High-Density Polyethylene (HDPE) is currently recyclable in some areas. This class includes milk, juice, and water jugs, base cups for some plastic soda bottles, as well as bottles for laundry detergent, fabric softener, lotion, motor oil, and antifreeze.

PVC (SPI=3)

Polyvinyl Chloride (PVC, also referred to simply as "vinyl") includes bottles for cooking oil, salad dressing, floor polish, mouthwash, and liquor, as well as "blister packs" used for batteries and other hardware and toys.

LDPE (SPI=4)

Low-Density Polyethylene (LDPE) includes grocery bags, bread bags, trash bags, and a variety of other film products. LDPE is currently being recycled by some of the major retail chains.

Polypropylene (SPI=5)

Polypropylene includes a wide variety of packaging such as yogurt containers, shampoo bottles, and margarine tubs. Also cereal box liners, rope and strapping, combs, and battery cases.

Polystyrene (SPI=6)

Polystyrene includes Styrofoam™ coffee cups, food trays, and "clamshell" packaging, as well as some yogurt tubs, clear carry-out containers, and plastic cutlery, Foam applications are sometimes called EPS, or Expanded Polystyrene. Some recycling of polystyrene is taking place, but is limited by its low weight-to volume ratio and its value as a commodity.

Other (SPI=7)

Can refer to applications which use some of the above six resins in combination or to the collection of the individual resins as mixed plastic (e.g., camera film can include several types of plastic resins). Technology exists to make useful items such as plastic ‘lumber’ out of mixed plastic resins, but generally the materials are more useful and valuable if separated into the generic resin types described above.

Metals

Aluminum

Included in this category are aluminum beverage cans, as well as clean aluminum scrap and aluminum foil. Currently, aluminum is a highly valued material for recycling.

Tin-Coated Steel Containers

Includes cans used for food packaging (i.e., canned foods). Some local recyclers may require cans to be cleaned and crushed with labels removed.

Bimetal Containers

A typical example includes tin-plated steel cans with an aluminum “pop top” (e.g., peanut cans). These containers can be separated from aluminum cans by using a magnet. (Note: Technically, tin cans are bimetal, but we do not consider them when referring to bimetal cans.) Many recyclers accept bimetal containers with tin-coated steel cans.

Non-Ferrous Metals

Includes most types of scrap metal which do not contain iron (such as copper and brass). This scrap can be a relatively valuable commodity, depending on quantity. It is often recycled through scrap metal dealers, although some general recyclers will handle it with other materials.

Ferrous Metal

Includes iron and iron-containing metal scrap. Ferrous metal is handled in the same manner as non-ferrous metal but generally has lower market value.

Compostables

Usually, compostable materials include food scraps and yard trimmings. Paper that cannot be recycled also can be composted.

Yard Trimmings

Includes landscaping debris, grass clippings, branches, and leaves. There are largr-scale facilities which compost yard trimmings, producing a product which can be used for mulch, potting soil, landfill cover, and soil amendment, Also, composting can be performed directly on site or in backyards.

Miscellaneous Recyclable

Lead-Acid Batteries

Lead-acid batteries are used in automobiles, back-up lighting systems, lawn mowers, and computers. Lead-acid batteries contain lead, a toxic metal, and sulfuric acid. Many states prohibit disposal of lead-acid batteries in municipal solid waste, and many require either retailers, wholesalers, or distributors to take back batteries. Currently, about 90 percent of lead-acid batteries used in automobiles are recycled.

Household Batteries

Household batteries come in a variety of types, including alkaline, carbon-zinc, mercuric-oxide, silver-oxide, zinc-air, and nickel-cadmium, Currently, only button batteries containing mercury and silver or nickel-cadmium batteries can be recycled, often at a net cost.

3.7 Solid Waste Laws

3.7.1 Solid Waste Management in Turkey

Household Waste Management :

Legislation and Enforcement:

Turkish Environment Law came in force in 1983 (Law no: 2872). According to paragraph (1) of Article 8 of this Law, it is prohibited to introduce into store in, transport to or remove from the receptor area any discharge or waste in such a way directly or indirectly in contradiction with the standards and methods specified in the pertinent regulations or to engage in similar activities (Kocasoy, Atabarut & Nuhoğlu, 2002).

The Solid Waste Control Regulation, which became effective on the 14 Th. Of March 1991, aims to control the negative effects on environment being sourced by the huge amount of urban solid waste on the open dumps. This regulation also provides the certain financial facilities needed to serve for the collection, transportation and disposal of solid waste with a certain system in the whole country. Meanwhile, the regulation is the legal base for the studies on recollection and evaluation of packaging waste in our country.

The regulation is based on three fundamental principles providing guidance on waste management;

- Production of less waste (waste minimization)
- Recovery of waste
- Disposal of waste without causing environmental damage

According to The Municipalities Law (Law no: 1580) the collection and transportation of waste is the responsibility of the district municipalities within the greater municipality, although greater municipalities have a responsibility for street sweeping and waste collection on main roads. Municipalities are additionally responsible for construction and operation of separation, disposal and composting facilities.

Recycling Activities

Waste reduction (waste minimization, reuse, recycling, recovery and composting) is an integral part of national waste management strategy. Separation and recycling of secondary materials from mınicipal solid waste is already well established in Turkey. There are several kinds of waste materials that should be recovered from solid waste. The major materials include; (1) glass bottles, (2) paper and paper products, (3) plastic products, (4) can bottles such as steel and aluminium, (5) metal including copper, iron, steel, aluminium.

The topic ‘recycling of solid waste’ involved in the Regulation, impose some responsibilities on producers for recollection and evaluation of liquid food packaging of ‘use-dispose’ type, in accordance with the ‘polluter pays’ principle in the Environment Law. Nowadays economic tools such as tax, quota, involvement share are being used for waste disposal. In Turkey, ‘quota-deposit’ among economic tools was begun to be used in order to reduce environmental pollution originating from packaging wastes.

Hazardous Waste Management:

Legislation and Enforcement:

Turkey has become party to international Basel Convention on the Control of the Transboundary Movements of Hazardous Wastes and Their Disposal on 20 September 1994. By taking this Convention as a base the National Hazardous Waste Management Legislation was prepared and published in official paper on 14 March 2005 (Kocasoy, Atabarut & Nuhoğlu, 2002).

Under Turkish Legislation hazardous wastes were defined according to:

- Reasons why materials are intended for disposal
- Disposal operations
- List of hazardous characteristics
- Constituents of potentially hazardous waste
- Activities which may generate potentially hazardous waste

Legislation contains a list of general types of waste to be controlled under this list there exist all wastes possessing a Turkish code number, probable constituents likely sources of arising, probable hazards and legally accepted disposal methods.

The Regulation include:

- Controls on the import of hazardous waste;
- Encouragement of the minimisation of hazardous waste at source;
- Requirements for producers to register with, and for collection and disposal contractors to obtain licences from the Ministry;
- Continuous ‘cradle to grave’ accountability;
- Powers for the Ministry to;
    - Ensure co-operation and co-ordination
    - Determine waste characteristics and define hazardous wastes
    - Approve plans and locations for plants
    - Licence treatment and disposal plants
    - Establish a commission for waste management
- Powers for Governors to;
    - Ensure waste management plans are applied within their provinces
    - Convey applications for treatment and disposal plants from municipalities to the Ministry of Environment
    - Issue licences to firms operating waste transport in their province
- Powers for municipalities to develop or have developed on their behalf, treatment and disposal plants for hazardous wastes.

In the table 3.6 shown in regulations for solid waste management in Turkey:

Table 3.6 Current Laws and Regulations for Solid Waste Management in Turkey

Law/Regulation	**Date of Issue**	**No. Of the Official Gazette**
Environment Law	11 / 08 / 1983	Official Gazette No. 18132
Solid Waste Control Regulation	14 / 03 / 1991	Official Gazette No. 20814
Medical Waste Control Regulation	20 / 05 / 1993	Official Gazette No. 21586
Hazardous Wastes Control Regulation	14 / 03 / 2005	Official Gazette No. 22387
Packaging and Packaging Waste Control Regulation	30 / 07 / 2004	Official Gazette No. 25538

3.7.2 Solid Waste Management in EU

Reviews and updates of EU waste management policy is given in the 'Communication on the review of Community Strategy for Waste Management, 1996'. This policy confirms the waste 'hierarchy of principles' that is established in the 'Community Strategy for Waste Management: Prevention, Recovery, and lastly Safe Disposal'.

The EU waste management policy says that waste should be disposed of in one of the nearest appropriate installations and that waste generated within the EU should not be disposed of elsewhere. So, this policy is based on proximity and self-sufficiency that apply to waste destined for disposal rather than to waste destined for recovery.

EU Law:

European legislation has strong influence on the national waste policies. New directives are always compromises between front runners who want to have higher standards, and laggards in waste management who prefer to avoid any obligations. The directives that have binding targets are the most debated, but also have the strongest impact. EU solid waste laws are indicated in figure 3.9.

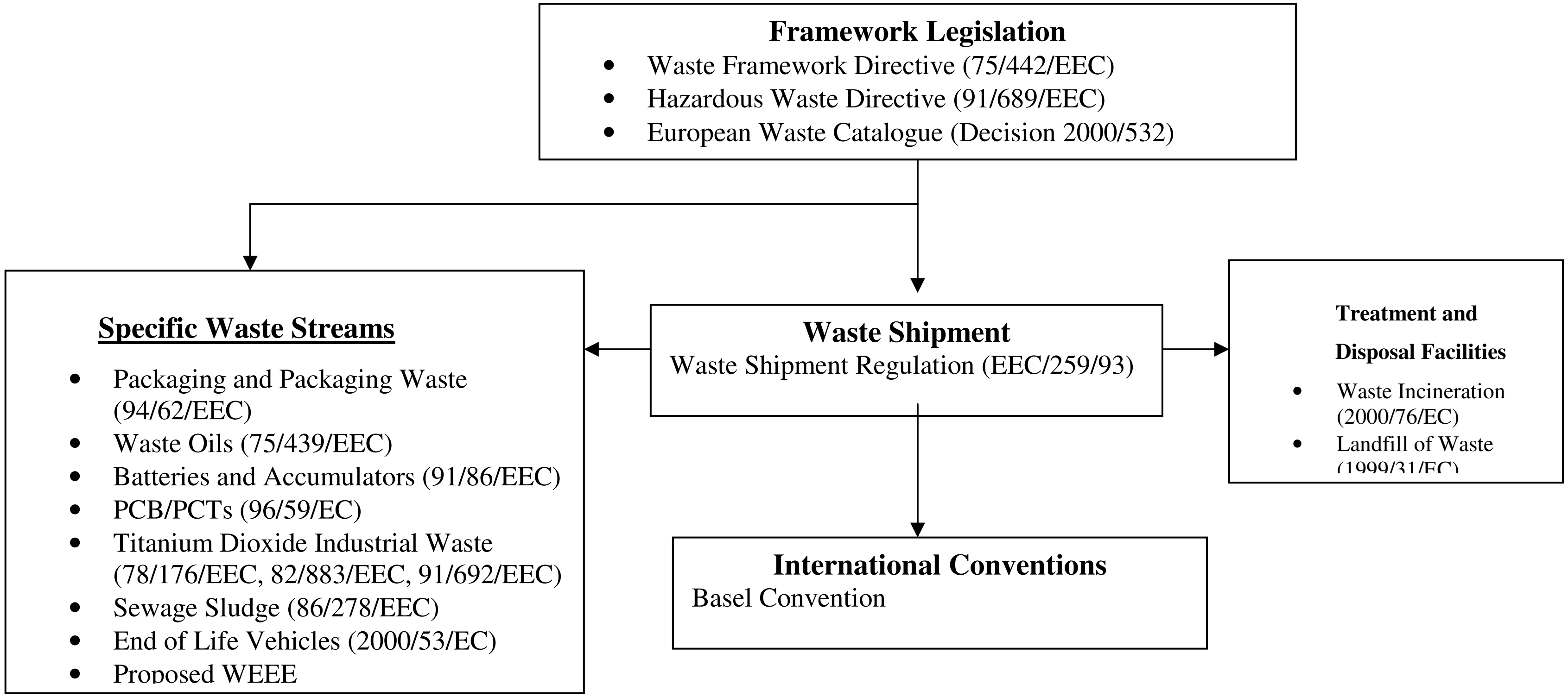


Figure 3.9 EU Solid Waste Laws

Waste Framework Directive

Directive 75/442/EEC

Amended by directives 91/156/EEC, 91/692/EEC/, 96/350/EC, 96/59/EC

This directive is the framework for management of all waste. MSW is only part of all waste. In forms the basis for all following directives.

The framework directive prescribes central principles:

- The waste management hierarchy: Prevention, re-use, recycling and recuperation of energy and materials get priority.
- Principle of Best Available Technology (BAT): disposal facilities must be equipped with the best available technology. The BAT is selected on technological, environmental and economical criteria.
- Principle of proximity: Waste must be treated as close as possible to the place of production or collection.
- Principle of Self-Sufficiency: Every member state, every community is responsible of its own waste.
- Polluter Pays Principle (PPP): Waste disposal facilities must not be paid by tax payer's money, but by the polluter.

Packaging and packaging waste directive

Directive 94/62/EEC

The law prescribes high recycling rates and high standards for disposal facilities. The law introduces the Extended Producer Responsibility principle. It is the producer, the industry, that is responsible for monitoring and achieving the targets.

The directive installed minimum standards:

- Every member states has to set up a system of return and collection of used packaging
- In line with the waste hierarchy the directive sets 5 year targets for recovery of energy and material and recycling of materials:
    - Recovery: 50-65% (min-max)
    - Recycling: 25-45% (min-max)
    - Minimum 15% recycling for every packaging material
    - Portugal, Greece and Ireland get 5 years extra

The directice so important because it contains quantitative targets. In 2001 the European Comission did a proposal for higher recovery and recycling rates for 2006. Recovery should be between 60-75% and recycling between 55-70%. The minimum targets for glass, paper, metals and plastics will be reinforced up to respectively; 60, 55, 50 and 20% (Anonym, 2003).

Landfill directive

Directive 99/31/EEC

The aim of the directive is to prevent or reduce negative impacts of landfilling on the environment and health risks.

The directive prescribes following measures:

- Treating waste before landfilling
- Phasing out co-disposal
- Supervising closure and aftercare: it is not enough anymore to simply dump soil on an old landfill to put it out of sight
- In the line with the PPP a min price for landfilling is defined. Pre-treatment costs, investment costs, operating costs, cost of closure, after care, financial provisions have to be included in the price

- o Targets are set to reduce the amount of biodegradable waste sent to landfills. The base is the amount of municipal biodegradable waste in 1995.
- o 2006: 75% of biodegradable waste sent to landfill
- o 2009: 50% of biodegradable waste sent to landfill
- o 2016: 35% of biodegradable waste sent to landfill

Incineration directive

Directive 2000/76/EU

The aim is the prevent and reduce pollution of air, water, soil and damage to human health by incineration.

The directive prescribes technical standards for incineration facilities. Emissions of CO, HCL, Total Organic Carbon (TOC), HF, SO_2, NO, NO_2, dioxins, ... are limited (Anonym, 2003).

Waste transport directive

Directive EEC/259/93 and 94/721/EEC

The aim is to regulate imports and exports of waste inside and outside the EU.

The transport directive divides the waste in three lists and sets priorities for each list:

- o Green list: Free transport (just notification to goverment) e.g.: sorted MSW
- o Orange list: Limited transport e.g.: unsorted MSW
- o Red List: Transport restricted strongly e.g.: hazardous waste

Products on the green list can be traded freely. Products on the orange and red list are restricted and fall under the principles of Proximity and Self-sufficiency.

3.7.3 Solid Waste Management in USA

Environmental Protection Agency

Congress created the EPA in 1970 to administer environmental programs and establish standards to protect the environment in a way that is consistent with U.S. goals. The EPA is the primary agency responsible for protecting the environment, but many other agencies are involved in particular areas as well. The EPA's duties include enforcement of air and drinking water quality standards, stream discharge standards, solid and hazardous waste treatment and disposal standards, and the cleanup of abandoned hazardous waste sites. The agency headquarters is in Washington, D.C., and regional offices are in Atlanta, Boston, Chicago, Dallas, Denver, Kansas City, Philadelphia, San Francisco, Seattle, and New York.

States also have agencies that enforce state environmental laws and regulations and, in many cases, federal regulations as well (with the help and advice of the EPA). State and local governments have the right to adopt environmental laws that are at least as stringent as federal laws. In fact, many state laws are identical to federal laws. Others, such as those in California, are even stricter than federal laws. Interested parties should contact the appropriate EPA regional or state regulatory personnel for up-to-date information on regulatory requirements (Shah, 2000).

Methods of Regulation

A permit is required for each point-source discharger (e.g., city or industry). Acquiring such permits not only necessitates gathering substantial information but also may require significant lead time before such a permit can be issued. The permit must state the type of pollutants that may be discharged and the allowable limits of such discharge. The discharger must monitor the various pollutants, keep their discharge below the permitted levels, and submit periodic reports to the EPA or the corresponding state agency. When the discharger violates its permit conditions, it must notify these agencies within a specified period of time that depends on the relevant environmental laws, which include the Clean Air Act, Clean Water Act, and Emergency Planning and Community Right-to-Know Act. The extent of the violation of the act, why it occurred, and what is being done to prevent future violations must be reported.

National Environmental Policy Act

On January 1, 1970, President Nixon signed the National Environmental Policy Act (NEPA). Since NEPA was passed, the courts have broadly interpreted its regulations to cover almost every activity that affects the environment and, at the same time, requires a federal permit or uses federal lands or funds. Many states have enacted legislation similar to NEPA for projects not covered by federal regulations. NEPA has been the basis for several environmental lawsuits as well.

The heart of NEPA is the requirement that federal agencies complete an environmental impact statement (EIS) before taking any major action that may have a significant environmental impact. The EIS is a complex, time-consuming, and expensive document to prepare (Cheremisinoff, 2003).

An EIS is required for any major federal action that significantly affects the human environment. Thus, proper analysis of three components is essential: the action must be federal, must be major, and must significantly affect the quality of the human environment. The first component can be the most misleading. Often, state and even private actions may trigger the EIS requirement if there is some substantial federal connection. For example, in Maryland Conservation Council v. Gilchrist, the U.S. Court of Appeals for the Fourth Circuit held that a state highway construction project was a major federal action, because the highway would cross a state park that was established with a substantial federal grant and approval from the Secretary of Interior was necessary to convert the parkland into a highway. For an action to be "major," it must be more than merely routine: simply put, projects must involve substantial expenditures of time, money and resources. Because of the statute's failure to define the "human environment," however, the courts have struggled to find a workable formula for determining when the human environment is affected.

Occupational Safety and Health Act

The Occupational Safety and Health Act of 1970 regulate hazards in the workplace, including exposure to hazardous substances, to protect the health and safety of employees. The act is administered by OSHA, which excludes suppliers who fail to meet minimum work conditions from bidding on public contracts. The act also provides penalties, including civil and criminal sanctions, for those suppliers. Among its many provisions, employers are required to keep up-to-date health records for employees exposed to chemical substances.

Solid Waste Disposal Act and Resource Recovery Act

The Solid Waste Disposal Act of 1965 was the first significant step in the federal regulation of solid waste disposal in an effort to improve waste disposal technology. Its main aim was the regulation of municipal waste. Increasing concerns over public health and the environment, however, led to the need for better management of solid waste and supported resource recovery. In turn, this led to the amendments of the 1965 act by Pub L No 95-512, and finally, in 1970, the Resource Recovery Act was passed. This act vastly expanded federal involvement in the management of solid waste, redirecting the emphasis from disposal to reduction, recycling, and energy recovery. By the mid-1970s, both the Congress and the public recognized that additional regulations were needed to ensure proper management of solid waste. These concerns prompted Congress to pass the Resource Conservation and Recovery Act of 1976 (Shah, 2000).

Toxic Substances Control Act

The Toxic Substances Control Act (TSCA) was enacted by the Congress in 1976 to regulate the manufacturing, processing, and distribution of chemical substances that pose a risk to human health or the environment. A “catch-all” statute, the TSCA was intended to cover the gaps between federal statutes regulating particular types of chemicals (e.g., pesticides, food, drugs, cosmetics, nuclear material) by regulating the manufacturers and processors of any chemical not regulated under another statute.

Under the TSCA, the EPA requires chemical manufacturers and processors to provide data about the health and environmental effects of chemicals that may present an "unreasonable" risk and enter the environment or that may present the likelihood of "substantial human exposure." After reviewing the data, the EPA may then issue regulations to reduce the risk to public health or the environment. In the case of imminently hazardous chemicals, the EPA may seize those chemicals through court action or prevent their release through a legal injunction. In addition to enforcement by the EPA, the statute also allows for citizen's lawsuits and contains a "whistleblower" provision. The manufacture, processing, and distribution of products containing polychlorinated biphenyls (PCBs) are banned under TSCA, which thus requires that the EPA promulgate regulations covering the storage and disposal of PCB-contaminated products and wastes.

Resource Conservation and Recovery Act

The Resource Conservation and Recovery Act (RCRA) of 1976 increased controls on nonhazardous solid wastes and began the regulation of hazardous wastes. Revisions to RCRA were made in 1980 and again in 1984.

The portions of the RCRA that regulate hazardous waste are contained in a section designated as Subtitle C. It contains expanded provisions for the management of hazardous wastes. Subtitle D covers solid waste disposal, and Subtitle I regulates underground tanks.

The RCRA also established a "cradle-to-grave" system to regulate hazardous waste from its generation, usually in the course of manufacturing or other commercial activities, to its final disposal. This approach has several key elements:

1) A tracking system in which a manifest document is required for every waste that is transported from one location to another.

2) A permit for the operation of facilities that treat, store, or dispose of hazardous waste.

3) A system of controls and restrictions on the disposal of hazardous waste on land.

Hazardous waste is frequently transported from the source to treatment, storage, or disposal facilities. To eliminate any possibility of improper handling during such transport, the waste generators are required by the EPA to complete a hazardous waste manifest form that must accompany the waste when it leaves the site.

In addition, the RCRA requires that permits be obtained for treatment, storage, and disposal facilities that accept hazardous waste. This permitting system gives the EPA the power to inspect such facilities, enforce standards and requirements, and take legal actions against violators of the RCRA regulations.

Hazardous and Solid Waste Amendments of 1984

During the early 1980s, the EPA was blamed by both the public and the Congress for failing to carry out their mandate. The Congressional response was to pass the Hazardous and Solid Waste Amendments of 1984 (HSWA). The scope of the RCRA regulations was greatly broadened through these amendments (Shah, 2000).

The HSWA was more detailed than most other pieces of environmental legislation. It prohibited the disposal on land of wastes that did not meet specific treatment standards. Land disposal of bulk and noncontainerized liquid hazardous waste was also prohibited. A major theme of the HSWA was the protection of groundwater. In addition, minimal technical requirements for land disposal facilities were included rather than leaving such technical details to the EPA, which was unusual. The HSWA also established standards for issuing permits, controls on underground storage tanks, and penalties for violating the law.

Comprehensive Environmental Response, Compensation, and Liabilities Act

The RCRA and the HSWA focused on existing and future hazardous waste management, but they failed to deal with older pollution problems such as the many existing, inactive hazardous waste disposal sites, which posed a serious threat to public health and the environment. Therefore, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 -better known as the "Superfund Act"- became law. This act provided for liability, compensation, cleanup, and emergency response for hazardous substances released into the environment and for the cleanup of inactive hazardous waste disposal sites. CERCLA was generally intended to give the EPA the authority and the funds to clean up abandoned waste sites and to respond to emergencies related to hazardous waste. The law provided for both a response and an enforcement mechanism.

Money for the Superfund came from a trust fund that was created using special taxes on crude oil and chemical companies. In 1986, the CERCLA was reauthorized, and the trust fund was increased from $1.6 to $8.5 billion, with money from taxes on petroleum and chemical companies as well as from a special corporate environmental tax. The CERCLA revisions enacted in 1986 are designated as the Superfund Amendment and Reauthorization Act.

The National Contingency Plan prepared by the EPA pursuant to the CERCLA governs cleanup efforts by establishing procedures and standards for responding to the release of hazardous substances. At the same time, the EPA can sue any responsible parties it can locate for the reimbursement of cleanup costs, thus allowing the federal government to respond while trying to shift the financial responsibility to others. Thus, the Superfund covers cleanup costs if the site has been abandoned, the responsible parties elude detection, or the private resources are inadequate.

Emergency Planning and Community Right-to-Know Act

The Emergency Planning and Community Right-to-Know Act was passed in 1986. It requires written emergency response plans to deal with chemical releases and establishes a Toxic Release Inventory. Employers must report to the EPA and advise employees of any hazardous substances handled and their potential effects. The act also requires that information about any toxic chemicals stored or permitted to be released during the operation of commercial and manufacturing facilities be made available to the public. State and local governments as well as facilities either using or storing hazardous chemicals must have emergency plans for notification and response. These facilities must also report annually the amount and characteristics of certain toxic chemicals both on their premises and released to the environment.

Pollution Prevention Act of 1990

The Pollution Prevention Act of 1990 calls pollution prevention a “national objective” and establishes a hierarchy of environmental protection priorities as national policy. It also establishes recycling, treatment, and waste minimization as greater priorities than disposal in landfills. Among other provisions, the act directs the EPA to facilitate the adoption of source reduction techniques by businesses and federal agencies and to establish methods of measurement for source reduction.

CHAPTER FOUR
WASTE MINIMIZATION

4.1 Waste Minimization

Along with rapid industrialization, which has resulted in the rise of pollution, there is a growing concern about the quality of the living environment. Requirement on good quality of the living environment has resulted in the change in thinking of the whole concept of pollution control. Industries have traditionally treated the waste products before discharging them to the environment. Because the treatment occurs after the production of waste, this type of treatment is called 'end-of-pipe' treatment and this is being seriously questioned. The alternative solution, 'waste minimization', aims at reducing the pollution problem by dealing with it during the manufacturing process itself.

Waste Minimization refers to the use of source reduction and/or environmentally sounds recycling methods prior to treating or disposing of hazardous and non-hazardous wastes. Waste minimization includes source reduction practices that reduce or eliminate waste generation at the source and environmentally sound recycling practices where source reduction is not economically practical. Waste minimization does not include waste treatment, i.e., any process designed to change the physical, chemical, or biological character or composition of a hazardous waste or waste disposal. For example, compacting, neutralizing, diluting, and incineration are not waste minimization practices (EPA, 2003).

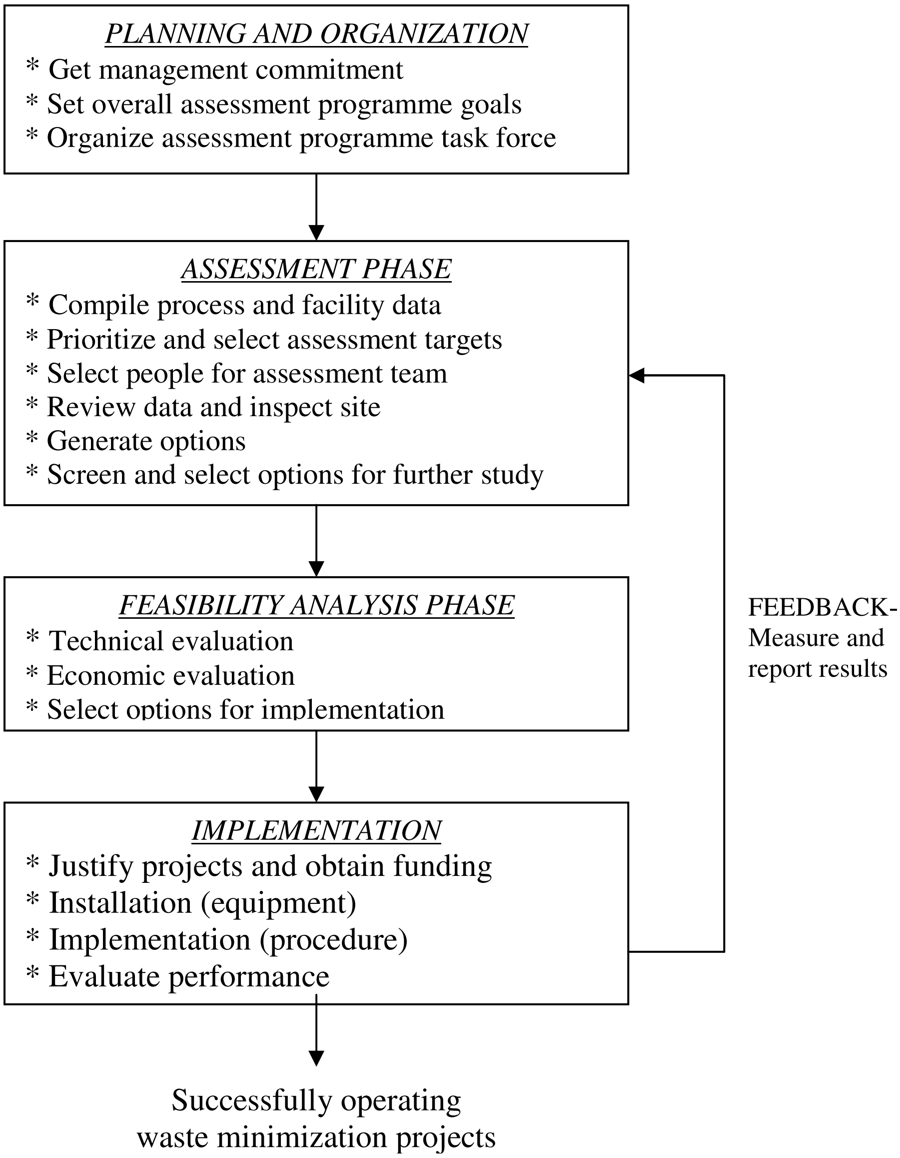
Many terms have been identified as synonymous with waste minimization:

- Pollution Prevention
- Conservation based environmental compliance
- Source Reduction
- Waste Reduction
- Pollution Reduction

- Clean Technology
- Environmental Technologies
- Low and Non Waste Technologies

4.2. Waste Minimization Assessment

A waste minimization assessment is a systematic planned procedure with the objective of identifying ways to reduce or eliminate waste. The steps involved in conducting a waste minimization assessment are outlined in Figure 4.1. The assessment consists of a careful review of a plant's operations and waste streams, and the selection of specific areas is established as the Waste Minimization Assessment focus, a number of options with the potential to minimize waste are developed and screened. Third, the technical and economic feasibility of the selected options are evaluated. Finally, the most promising options are selected for implementation (Daşçı, 1998).



<u>Begin the Waste Minimization Assessment Programme</u>

Figure 4.1 Waste Minimization Methodology

According to Figure 4.1, Planning and Organization is the first stage of a waste minimization assessment program. Assessment, which is the main stage, follows this first stage. The program concludes with Feasibility Analysis and Implementation Phases.

4.2.1 Planning and Organization

4.2.1.1 Get Management Commitment

The cooperation of participants of different disciplines, from a variety of internal, and possibly external departments is required for an effective waste minimization Program. They must be brought together in a flexible structure to maintain progress with the waste minimization assessment.

Firm commitment at the management level is a prerequisite to a successful program. The commitment of senior management can be demonstrated to the workforce in a number of ways. For example, specific waste minimization targets can be included into a job description in an environmental policy, or feedback can be encouraged in this area with a reward or bonus scheme. The policy should include: 1) a general management statement emphasizing the importance of pollution prevention (or waste minimization) and the company's commitment to pollution prevention principles. 2) defined goals or targets for pollution prevention 3) allocation of organizational and technical resources to pollution prevention, and 4) a method for tracking pollution prevention performance. An example management policy statement is stated below:

We, [company name], are committed to excellence and leadership in protecting the environment, In keeping with this policy, our objective is to reduce waste generation and emissions. We strive to minimize adverse impact on the air, water, and land through excellence in pollution prevention. By successfully preventing pollution at its source, we can achieve cost savings, increase operational efficiencies, improve the quality of our products and services, and maintain a safe and healthy workplace for our employees.

[Company name]'s environmental guidelines include the following:

- Environmental protection is everyone's responsibility. It is valued and displays commitment to [company name].
- Preventing pollution by reducing and eliminating the generation of waste and emissions at the source is a prime consideration in research, process design, and plant operations. [Company name] is committed to identifying and implementing pollution prevention opportunities through encouragement and involvement of all employees.
- Technologies and techniques, which substitute non-hazardous materials and utilize other source reduction approaches, will be given top priority in addressing all environmental issues.
- [Company name] seeks to demonstrate its corporate citizenship by adhering to all environmental regulations. We promote cooperation and coordination between industry, government, and the public toward the shared goal of preventing pollution at its source.

4.2.1.2 Organize Assessment Program Task Force

A waste minimization team, which is called the 'task force', is involved at all stages of the waste minimization process. Participants should be selected based on their relevant technical expertise, though often this favors senior employees and managers.

In practice, task force contributions from enthusiastic and open-minded junior staff have proved particularly successful in many cases. The inclusion of 'external' members can also prove a useful source of information. The task force should report directly to senior management representation.

4.2.1.3 Set Overall Assessment Program Goals

At the beginning, it is important to decide exactly what the waste minimization program is intended to achieve. This is usually:

- Cost saving
- Reduced environmental impact.

While most programs are primarily directed towards cost saving, it is important to bear in mind that any reduction in waste will have a positive environmental benefit. A flexible approach to goals is necessary in order to assess the impact of future changes/advances in technology, raw materials, economic instruments, and regulatory compliance.

4.2.2 Assessment Phase

4.2.2.1 Compile Process and Facility Data

This stage includes the collection of information on types, quantities, compositions and sources of every possible waste stream and generation of waste minimization options that warrant feasibility and cost benefit analysis. Certain methods refer to this information collection stage as the 'waste audit'.

Many aspects need addressing when calculating emission to the receiving environmental media. These may be listed as process yield, process controls, fugitive losses, housekeeping, waste disposal, and non-process waste e.g. office derived paper waste.

Sources of data available maybe:

- Management reports
- Production statistics
- Material use reports
- Bills of materials and other costings
- By-product and waste disposal records
- Customer and suppliers

The data collected should be combined with existing flow diagrams where possible to produce a waste flow diagram. Waste flow diagrams linked to a material (or mass) balance enable to assess the quality of data collected. They also product a yardstick for monitoring the process of the ongoing waste minimization program.

The principle of a mass balance is derived from the mass conservation principle, and formulated as below:

Mass in = Mass out + Mass accumulated

A detailed study to quantify each input and output of a process is required for a mass balance. Inputs include raw materials, ancillary materials e.g. cleaning materials, supplier packaging, and consumables e.g. disposable gloves, whereas output materials can be product losses e.g. spillages, by product of a process, rejected product, supplier and customer packaging and general waste e.g. non process office waste. In reality the technique is very difficult to apply with many potential problems, often related to defining the boundary of the study, the complexity of process, and the quality of available data. Once complete, data from a mass balance can be illustrated in the form of a Sankey Diagram which is defined in Table 4.1.

4.2.2.2 Prioritize and Select Assessment Targets

To focus attention on the most significant waste problems, a selection process is required. Thus, the waste streams resulting from similar operations and these with similar waste derived problems can be effectively grouped together.

The presentation of results in a simple chart can be used to summarize the findings of the data collection at the prioritization stage. This method will enable easy understanding and generate discussion. Examples of chart types are given in Table 4.1.

Table 4.1 Examples of chart types for data presentation

FORMAT	DESCRIPTION
Pie Chart	Relative data are shown in the form of a circular pie. This is a useful chart to use when the absolute total is less significant than the relative size of one portion to another.
Histogram	Takes the form of a bar chart which can be used to illustrate numerical values in a range of categories
Pareto Analysis	A form of histogram where the categories are ranked in order of size. Used to highlight the "significant few"
Sankey Diagram	Horizontal bar chart showing the fate of input materials in proportion to the width of the bars. Extremely useful in showing recycle streams (rework, reprocessing, corrections, etc.) that are difficult to show on a pie chart.

4.2.2.3 Review Data and Inspect Site

A site inspection is a particularly useful tool for assessing areas often poorly documented or ignored. The site visit should address matters of concern, such as any conflicting data. Interviews with operators (to establish their knowledge of procedures). Modifications since the last available process diagram, and a comparison of the actual procedures against work instructions should be fully documented to support the subsequent review and audit stages.

4.2.2.4 Generate Options

After the origins, quantity and nature of the waste streams have been identified, the waste minimization options can be generated. The following sources were identified as providing up-to-date environmental information in a recent survey:

- Seminars / workshops
- Exhibitions
- Publications

- Industry or trade associations
- Regulatory bodies
- Local networks / clubs
- Consultants
- Equipment suppliers
- Best practice guides

The identification of waste minimization options should be based on the hierarchy of waste minimization with pollution prevention considered in advance of recycling and reuse technologies.

4.2.2.5 Screen and Select Options

Once the options for waste minimization have been generated, the next stage of 'Screening and Selecting for Further Study' starts. This stage ensures that efforts are concentrated only on those options with the greatest potential for success. Concentration on every option can represent a significant dilution on both manpower and financial resources. Therefore the less practical or cost effective options should be eliminated at this stage. Options with widely accepted benefits that require little or no capital investment should be selected for immediate implementation. Remaining options will require screening and ranking as a means of prioritizing the efforts of the task force. There are a number of screening processes. A complex process with a large specialized task force and many options may favor a more formal approach, whereas a small task force investigating a limited number of options for a relatively simple process any debate each option informally.

Three types of screening techniques are given below:

- The Weighted Sum Technique: This is a quantitative method that ranks alternatives based on a set of pre-defined criteria. According to this method, each option is rated using a scale of 0-10 against a number of key criteria. Subsequently, the algebraic sum of all the criteria of each option is calculated and compared with other options. This technique is widely accepted for ranking alternatives that offer differing benefits at variable costs.

- A relatively simple version uses four fixed criteria which are the position of the option with respect to the waste management hierarchy, the potential for implementation, the type of option (e.g. housekeeping versus novel technology), and the cost of the option.

- Another method of rating and ranking is based on different criteria and an estimate of the "frequency of occurence". Suggested ratings vary from +5 for a significant improvement, through 0, for no impact, to -5, for a significant deterioration. The criteria are the emission reduction, effect on process efficiency, and effect on the economic operation of the plant. In addition the frequency of occurence is also estimated.

4.2.3 Feasibility Analysis Phase

Screening identifies the best options for minimizing waste. However these options must be subjected to technical and economic feasibility analysis to prioritize them for implementation.

Technical feasibility is, of course, paramount. However, it is likely that, by this stage of the problem-solving process, this has already been assessed. Financial appraisal enables the technically feasible options to be prioritized. Financial appraisal has four objectives:

- To determine which investments make the best use of the organization's money
- To ensure optimum benefits from each of these investments;
- To minimize risk to the enterprise
- To provide a basis for the subsequent analysis of the performance of each investment.

4.2.4 Implementation

Once agreement and funding has been finalized, the implementation procedure begins involving stages common to all capital projects. These stages are planning, design, procurement, and construction.

When implementing any waste minimization initiative, it is important to prepare carefully and follow a structured plan.

Before making any changes, it is important to set up a system to monitor their effectiveness once in place. This measurement system may well be the one constructed to aid data collection.

The next steps are then to implement the system and monitor it to ensure that the desired outcome is achieved. In any improvement process, it is essential to measure and evaluate the results of the implemented changes. This enables successes to be quantified, failures understood, and new targets to be set.

CHAPTER FIVE
INDUSTRIAL SOLID WASTE MINIMIZATION

5.1 Waste Minimization Techniques

As it was mentioned before, the waste elimination takes place at the top of the waste minimization hierarchy while the source reduction and recycling are also the recommended methods, as shown in Figure 5.1. The source reduction and recycling are the two methods of waste minimization techniques.

Source reduction is divided into four sub-categories, which are good operating practices, technological changes, input materials change, and products change. These four categories are all site-specific and affect the manufacturing activities directly.

The second method of the waste minimization technique is recycling. Recycling is divided into two main groups such as on-site recycling and off-site recycling. The on-site recycling is also called in-plant recycling which is done within the premises of the plant. It is a relatively well-developed technology, because it has been practiced by the process industries for a long time. The researches may be needed to reach the desired purity in the recycling activity. The material that is recycled on-site is cleaner and more homogeneous than the one recycled off-site. Generally off-site recycling cannot offer more qualified products like on-site recycling. Off-site recycling is usually applied for the wastes, which are not to be used in the process again. It also called post-production recycling which is done at a different plant in the recycling sector.

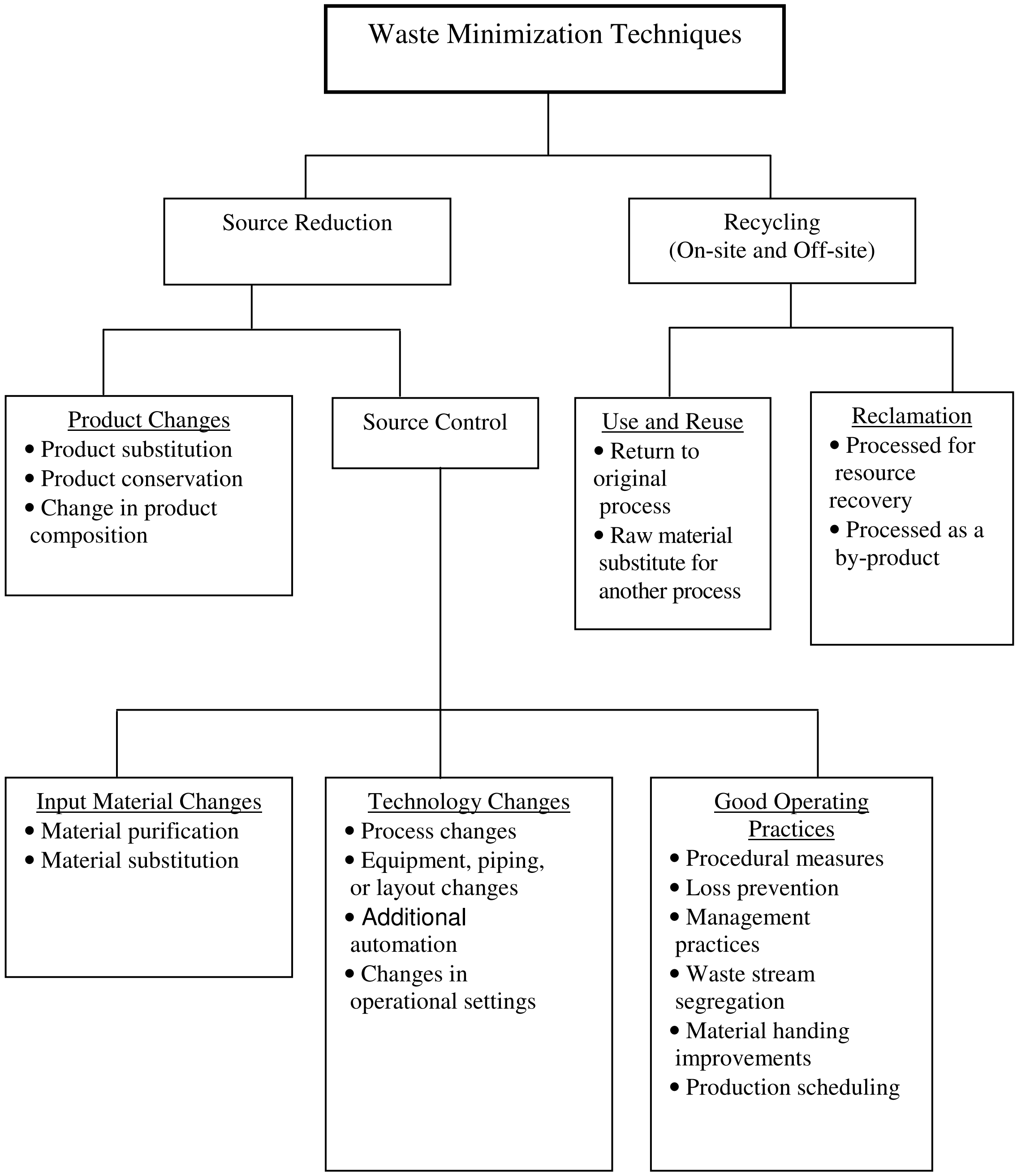


Figure 5-1 Waste minimization techniques. (Shah, 2000)

Waste Reduction Techniques

If a clean technology is regarded as one that reduces waste generation, and/or material and energy usage, then it can be seen that what may be regarded as a cleaner technology in one industrial sector or application is not necessarily so regarded in another sector. For example, distillation is widely used throughout the chemical industry to recover materials for reuse. Consequently, it would not normally be regarded as a clean technology in this context. Research is ongoing to attain better and more energy efficient separation techniques. On the other hand, in a small paint spraying operation, which produces pigment-contaminated solvents, the installation of a small distillation column for solvent recovery would indeed be a cleaner technology (Freeman, 1997).

It can thus readily be seen that there is no panacea for reducing wastes. Nevertheless, several general guidelines have been established, which can be supplemented by examples gleaned from experience. The techniques for bringing about waste reduction can be broken down into four major categories as follows:

- Inventory management
  - Inventory control
  - Materials control

- Production process modification
  - Operational and maintenance procedures
  - Materials change
  - Process equipment modification

- Volume reduction
  - Source segregation
  - Concentration

- Recovery
  - On-site
  - Off-site

It should be noted that waste reduction techniques are generally used in combination so as to achieve maximum effect at the lowest cost. It is important to realize that the impact of a waste reduction technique on all waste streams must be considered. For example, switching from solvent-based to water-based methods may result in lower organic emissions to atmosphere, but can lead to an increased burden on wastewater treatment.

Inventory Management

Proper inventory control over raw materials, intermediate products, final products and the associated waste streams is an important waste reduction technique. In many cases waste is just out-of-date, off-specification, contaminated, or unnecessary raw materials, spill residues or damaged final products. The cost of disposing of these materials not only includes the actual disposal costs but also the cost of the lost raw materials or product. Inventory management incorporates both inventory and material control (Freeman, 1997).

Inventory control: Inventory control involves techniques to reduce inventory size and hazardous chemical use while increasing inventory turnover. Proper inventory control can help reduce wastes occurring as a result of the following: excess, out-of-date and no-longer-used raw materials. Methods that can be used are purchasing in small quantities, purchasing in appropriate container sizes and just-in-time purchasing.

Material control: It is essential to have proper control over the storage of raw materials, products and process waste and the transfer of these items within the process and around the facility. This will minimize losses through spills, leaks or contamination. It will also ensure that the material is efficiently handled and used in the production process and does not become waste. A list of typical sources of losses is given in Table 5.1.

Table 5.1 Potential sources of process material loss

Loading	Source
Loading	Leaking fill hose or fill line connections
	Draining of fill lines between filling
	Leaking valves, piping and pumps
Storage	Overfilling of tanks
	Improper or malfunctioning overflow alarms
	Leaking transfer pumps, valves and pipes
	Lack of regular inspection
	Lack of training programme
Process	Leaking process tanks
	Improperly operated and maintained process
	Leaking valves, pipes and pumps
	Overflow of process tanks; improper overflow
	Leaks and spills during material transfer
	Open drains
	Equipment and tank cleaning
	Off-specification raw materials

Production Process Modification

Waste can be significantly reduced by improved process efficiency. Such improvements can range from simple, inexpensive changes in production procedures to the installation of state-of-the-art equipment. Three techniques for production process modification have been identified. These are improved operation and maintenance, material change and equipment modifications.

Operational and maintenance procedures: Improvements in operation and maintenance are usually relatively simple and cost effective, and may lead to significant waste reduction. The techniques used are not new, but have not generally been applied to waste reduction problems. A list of examples of operational changes is given in Table 5.2. A strict maintenance programme which stresses corrective and preventive maintenance can reduce waste generation caused by equipment failure.

Such a programme can help spot potential sources of release and correct a problem before any material is lost (Freeman, 1997).

Table 5.2 Examples of operational changes to reduce waste generation

Examples
Reduce raw material and product loss due to leaks, spills, drag-out, and off-specification process solution
Schedule production to reduce equipment cleaning, e.g. formulate light to dark paint so the vats do not have to be cleaned out between batches
Inspect parts before they are processed to reduce number of rejects
Consolidate types of equipment or chemicals to reduce quantity and variety of waste
Improve cleaning procedures to reduce the generation of dilute mixed waste with methods such as using dry cleanup techniques, using mechanical wall wipers or squeegees and using
Segregate wastes to increase recoverability
Optimize operational parameters (such as temperature, pressure, reaction time, concentration and chemicals) to reduce by-product or waste generation
Develop employee training procedures on waste reduction
Evaluate the need for each operational step and eliminate steps that are unnecessary
Collect spilled or leaked material for reuse

Material change: The replacement of materials, used in either a product formulation or in a production process, can either result in the elimination of a hazardous waste or facilitate recovery of a material. For example, CFCs are gradually being replaced by more ozone-friendly products. This is an example of eliminating a hazardous waste source. Replacement of a solvent by one with a different vapour pressure may allow separation and recovery by distillation, condensation, etc. Table 5.3 gives some examples of waste reduction through material change. As previously emphasized, care must be taken to examine the impact of changes on the total wastes from a process. This is particularly important in the case of material changes. The effect on aqueous wastes of changing from organic solvents to water is a case in point.

Table 5.3 Examples of waste reduction through material change

Industry	**Techniques**
Household appliances	Eliminate cleaning step by selecting lubricant compatible with next process step
Printing	Substitute water-based ink for solvent-based ink
Textiles	Reduce phosphorus in wastewater by reducing use of phosphate-containing chemicals Use ultraviolet light instead of biocides in cooling towers
Air conditioners	Replace solvent-containing adhesives with water-based products
Electronic components	Replace water-based film-developing system with a dry system
Ink manufacture	Remove cadmium from product
Plumbing fixtures	Replace hexavalent chrome-plating bath with a low-concentration trivalent chrome-plating bath
Pharmaceuticals	Replace solvent-based tablet-coating process with a water-based process

Process equipment modification

The installation of more efficient equipment or the modification of equipment can reduce the generation of waste. Modifications may be simple, such as improved mixing, or better pump seals. On the other hand, installation of completely new equipment may be involved. In most cases the investment will pay for itself in a relatively short space of time, due to increased production rates, reduced waste handling costs, etc. Some examples of process modifications are given in Table 5.4.

Table 5.4 Examples of production process modifications for waste

PROCESS STEP	TECHNIQUE
Chemical reaction	Optimize reaction variables and improve process
	Optimize reactant-addition method
	Eliminate use of toxic catalysts
	Improve reactor design
Filtration and washing	Eliminate or reduce use of filter aids and
	Use counter-current washing
	Recycle spent washwater
	Maximize sludge dewatering
Parts cleaning	Enclose all solvent cleaning units
	Use mechanical cleaning devices
	Use plastic-bead blasting
	Install drag-out recovery tanks
	Use high-solids coatings
	Use powder coating systems
Equipment cleaning	Use high-pressure rinse system
	Use mechanical wipers
	Reuse spent rinse water
	Use compressed gas to blow out lines
Spills and leaks	Use bellow-sealed valves
	Install spill basins or dikes
	Use seal-less pumps
	Install splash guards and drip boards

Volume reduction

While reduction in volume does not, of itself, constitute waste reduction, it frequently facilitates separation and recovery. The reduction in volume may involve complex concentration technologies or may simply consist of source segregation.

Source segregation

This very simple operation is a basic tenet of good waste minimization. The segregation of wastes allows them to be more readily removed or recovered. For example, the mixing of small quantities of organic solvents with aqueous streams both militates against effective recovery and puts an increased load on biological treatment systems. Keeping the organic streams separate may allow recovery, incineration, etc. A commonly used waste segregation technique is to collect and store washwater or solvents used to clean process equipment (such as tanks, pipes, pumps or printing presses) for reuse in the production process. This technique is used by paint, ink and chemical formulators, as well as by printers and metal fabricators.

Concentration: The concentration of a waste involves the removal of some portion of it, e.g. water. There are many techniques available to enable wastes to be concentrated. These include physical separation of solids and liquids (filtration, centrifugation, gravity settling, etc.), membrane separations such as ultrafiltration, reverse osmosis, etc., as well as energy intensive operations such as evaporation.

Recovery

Waste recovery should only be considered after all other waste reduction options have been instituted. The recovery of waste costs money in terms of energy and/or material input. Reduction of waste generation at source is more cost effective, since it represents a reduction in lost raw materials, intermediates, products, etc. Nevertheless, since their will always be some waste generation, recovery represents a viable and cost effective waste management alternative. Effective recovery is enhanced by segregation of materials, as already outlined. Recovery may be carried out on-site or off-site. On-site recovery is preferable, where possible, since it reduces possible handling losses and allows the management of the waste to remain within the compass of the producer. On-site recovery is particularly appropriate where the recovered material can be reused as a raw material (Freeman, 1997).

Most on-site recovery systems will generate some type of residue (i.e. contaminants removed from the recovered material). This residue can either be processed for further recovery or properly disposed of. The economic evaluations of any recovery technique must include the management of these residues.

In the event that on-site recovery is not feasible, for economic or other reasons, off-site recovery should be considered. In some situations a waste may be transferred to another company for use as a raw material in the other company's manufacturing process.

Benefits of Waste Minimization

Waste reduction can save money and protect both public health and the environment. Money is saved by reducing waste treatment and disposal costs, raw material purchases, and other operating costs. In addition, the waste generator can reduce any potential environmental liabilities.

Many industries have realized the economic and environmental value of pollution prevention measures. These measures are technologies and practices that are designed to replace or improve current industrial practices so that wastefulness and pollution are reduced. It is often the case that a second look at a manufacturing process can identify how waste can be reduced, sometimes at very little cost (Shah, 2000).

5.1.1 Source Reduction

Source reduction can be achieved through product changes, good operating practices, technological changes, and input material changes.

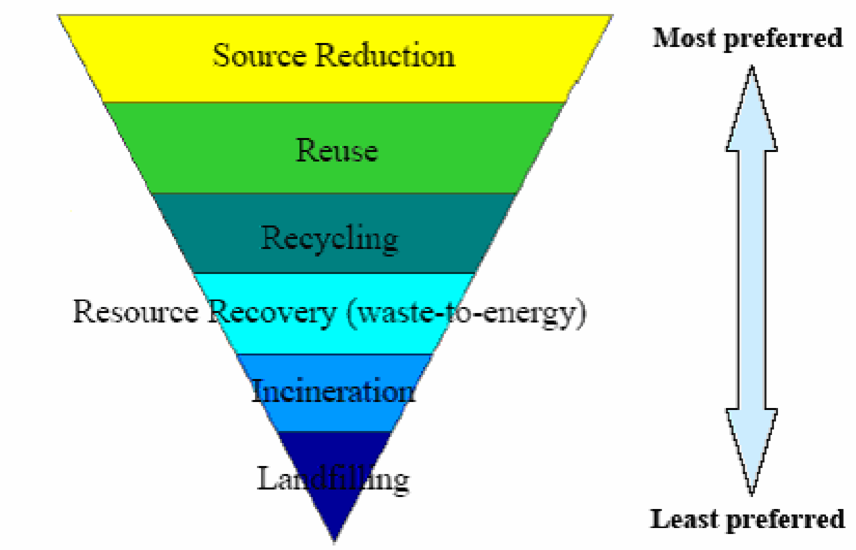


Figure 5.2 Solid Waste Management Hierarchy

Product Changes Product changes are performed by the manufacturer to reduce the waste resulting from a product's use. Product changes include product substitution, product conservation, and changes in product composition.

In the paint manufacturing industry, for example, water-based coatings are increasingly used in place of solvent-based paints. These products do not contain toxic or flammable solvents, which make solvent-based paints hazardous during disposal. In addition, cleaning the applicators (e.g., brushes, rollers) with solvents is not necessary (Shah, 2000).

Good Operating Practices Good operating practices are procedural, administrative, or institutional measures to minimize waste. These practices apply to the human aspect of manufacturing operations. Good operating practices include management and personnel practices, material handling and inventory practices, loss prevention, and waste segregation.

Management and personnel practices should focus on employee training and encouragement to reduce waste. Material handling and inventory practices include programs to reduce loss of input materials and to ensure proper storage conditions. Loss prevention minimizes waste by avoiding leaks from equipment and spills.

Waste segregation reduces the volume of hazardous waste by preventing hazardous and nonhazardous wastes from mixing.

Technological Changes Technological changes are oriented toward process and equipment modifications to reduce waste. Such changes can range from minor adjustments in processes to full replacement of processes, involving large capital costs.

Input Material Change Input material changes minimize waste by reducing or eliminating the hazardous material that enters the production process. Changes in the input materials can also be made to avoid generation of hazardous wastes within the production processes. Input material changes include material purification and material substitution.

5.1.1.1 Strategies for Source Reduction

There are many strategies available to accomplish source reduction. The EPA has identified the following examples of source reduction activities:

- Redesigning products or packaging to reduce the quantity or toxicity of the materials used, substitution of lightweight materials, or making them reusable
- Reusing existing materials, products, or packaging; for example, refillable bottles, reusable pallets, reconditioned toner cartridges, and copying on both sides of a sheet of paper
- Reducing the amount of a product or packaging used
- Lengthening the lives of products or materials to postpone disposal, such as through regular maintenance or choosing to repair an item
- Using packaging that reduces the amount of damage or spoilage to a product
- Managing organic waste (such as food scraps and yard trimmings) through on-site composting or other alternatives to disposal

In the Table 5.5 below the purchasing strategies for source reduction can be seen with the examples:

Table 5.5 Purchasing Strategies for Source Reduction

Strategy	**Examples**
Reduce product use	- Double-sided copies - Electronic mail and news
Rent or lease products or equipment or contract for services	- Rent tools that are needed only occasionally - Lease technological products (computers, copiers)
Purchase more durable products	- Long and extended-life products (tires, lightbulbs) - Extended warranties
Purchase products containing nonhazardous materials	- Green cleaning products - Water-based paints and inks - Reduce battery use
Purchase products with less packaging or reuse packaging	- Purchase concentrates - Avoid purchasing products with secondary packaging
Purchase products that are returnable, reusable, or refillable	- Refillable cups - Reusable utensils and dishware in cafeterias

5.1.1.2 Industrial source reduction

The EPA has provided the following list of items to increase industrial source reduction:

- Recover plant materials such as solvents, metal, paper, oil, and cooling water
- Increase production efficiency to reduce the generation of scrap material
- Limit production to what is required
- Reuse and repair used pallets
- Reuse and refill packaging containers, such as bags and drums
- Return packaging materials for reuse and/or reuse packing material
- Redesign products to prevent waste associated with packaging and manufacturing
- Use materials from a materials exchange program in place of virgin materials

In the Table 5.6 below the typical examples of industrial source reduction can be seen:

Table 5.6 Typical Examples of Industrial Source Reduction

Business	Method of source reduction	Revenue/savings
Dupont	Reuse of 25% of packaging materials	$3 million
Herman Miller, Inc.	Changing packaging design and switching to returnable packaging	270 tons of cardboard, 8 tons polystyrene, and $422,000
Johnson & Johnson	Reduced packaging waste since 1988	$2.8 million
Sprint	Printing two-sided telephone bills	450 tons paper annually
Quebecor Printing	Repairing and reusing broken shipping pallets	$14,000, repair costs 20% of new pallets
Asbury Park Press	Switching to cloth rags instead of disposable	$38,000 annually

5.1.1.3 Source Reduction Benefits

Source reduction, including material reuse, can help reduce waste disposal and handling costs, because it avoids the costs of recycling, municipal composting, landfilling, and combustion. Source reduction also conserves resources, such as water and energy, and reduces pollution, including greenhouse gases, that contribute to global warming (EPA, 2000).

Source reduction saves natural resources. Waste is not just created when consumers throw items away. Throughout the life cycle of a product—from extraction of raw materials to transportation to processing and manufacturing facilities to manufacture and use—waste is generated. Reusing items or making them with less material decreases waste dramatically. Ultimately, fewer materials will need to be recycled or sent to landfills or waste combustion facilities.

Source reduction reduces toxicity of waste. Selecting nonhazardous or fewer hazardous items is another important component of source reduction. Using less hazardous alternatives for certain items (e.g., cleaning products and pesticides), sharing products that contain hazardous chemicals instead of throwing out leftovers, reading label directions carefully, and using the smallest amount necessary are ways to reduce waste toxicity.

Source reduction reduces costs. The benefits of preventing waste go beyond reducing reliance on other forms of waste disposal. Preventing waste also can mean economic savings for communities, businesses, schools, and individual consumers (EPA, 2000).

- When these households reduce waste at the source, they dispose of less trash, resulting in lower trash disposal fees and longer landfill life. This reduces the cost of waste management to their community.

- Industry also has an economic incentive to practice source reduction. When businesses manufacture their products with less packaging, they are buying less raw material. A decrease in manufacturing costs can mean a larger profit margin, with savings that can be passed on to the consumer. Add decreased waste disposal costs to this, and significant savings can be achieved.

- Consumers also can share in the economic benefits of source reduction. Buying products in bulk, with less packaging, or that are reusable (not single-use) frequently means a cost savings. What is good for the environment can be good for the pocketbook as well.

5.1.2 Recycling

Reclamation. Reclamation is the recovery of valuable material from a hazardous waste. Reclamation techniques differ from use-and-reuse techniques in that the recovered material is not used in the facility; rather, it is sold to another company.

One photoprocessing company uses an electrolytic-deposition cell to recover silver from the rinsewater of film-processing equipment. The silver is then sold to a small recycler. By removing the silver, this wastewater can be discharged to the sewer without additional pretreatment by the company. This unit paid for itself in less than 2 years by the value of silver recovered.

The company also collects used film and sells it to the same recycler. The recycler then burns the film and collects silver from the residual ash. By removing the silver, this ash becomes nonhazardous as well.

Use and Reuse. Recycling via use and/or reuse involves the return of a waste material to the originating process (or to another process) as an input material. A printer of newspaper advertising in California, for example, purchased an ink-recycling unit to produce black newspaper ink from its various waste inks. The unit blends the different colors of waste ink together with fresh black ink and black toner to create the recycled black ink, which is then filtered to remove flakes of dried ink. This ink is used in place of fresh black ink, and it eliminates the need for the company to ship waste ink for off-site disposal. The price of the recycling unit was paid off in 18 months based only on the savings in purchases of fresh black ink. The payback improved to 9 months when the costs for disposal of ink as a hazardous waste were included.

CHAPTER SIX
SOLID WASTE MANAGEMENT IN THE BEER INDUSTRY

6.1 Industry Overview

This company's beer business today comprises a total of 16 breweries, 7 malteries and 1 hop processing facility in 6 countries, coupled with various companies for distribution, licensing and technical support. Currently total annual brewing capacity of the company is 31 million hectolitres whereas the total malting capacity is around 243,000 tonnes per annum.

In addition to the leading position of the company in the Turkish beer market, they have capitalized on their broad experience of working in emerging markets to seize the opportunities in the developing Eurasian countries.

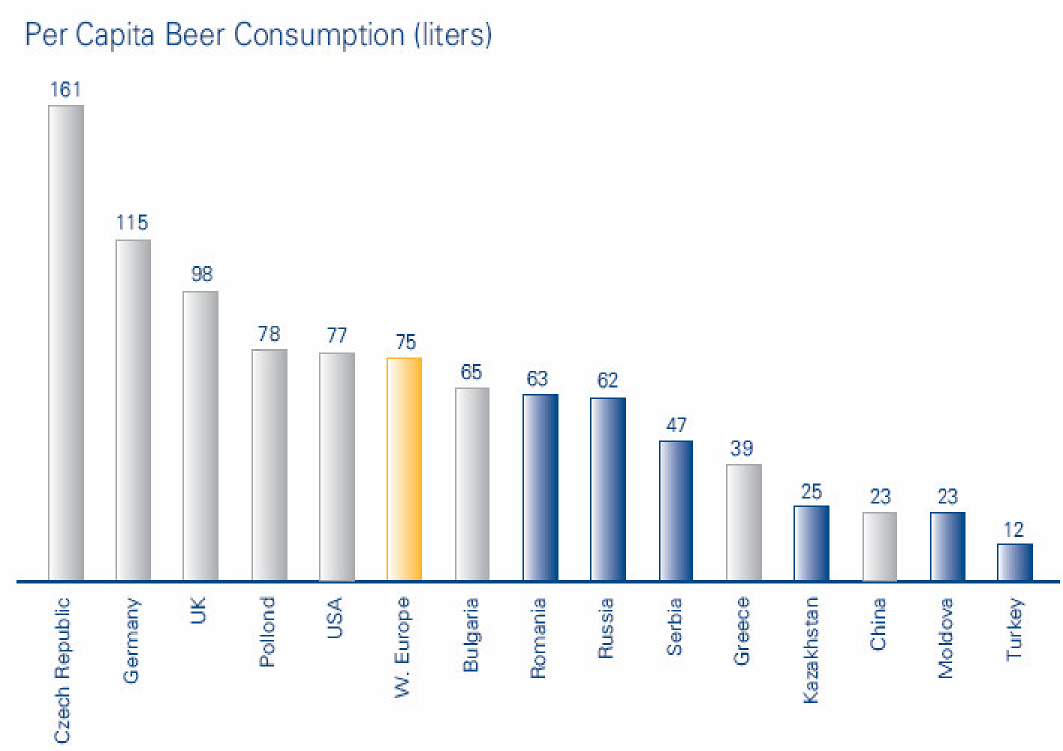


Figure 6.1 Per capita beer cunsumption (liters), 2005

6.1.1 Turkey Beer Operations

Turkey has a relatively young beer industry as far as the private enterprises are involved. Beer production in Turkey began in 1890 through a brewery founded in Istanbul by two Swiss entrepreneurs. Later on, this brewery was nationalized along with another one in Ankara in 1939, during when Tekel, which is a state enterprise, was the only beer producer in Turkey.

Following a change in the regulations in 1955, that allowed private enterprises to produce beer, the first two breweries started the production of a local brand in 1969. Since then, the Turkish beer market has shown significant growth.

At the end of 2004 per capita beer consumption in Turkey reached 11 litres from a base of 4 litres in 1986. Even after this significant growth, per capita consumption in Turkey is still low compared to averages of Europe, US or even Eastern Europe. In addition, there are other fundamentals that support the growth of the market.

Factors that may be listed in that respect include the favorable demographics of Turkey. Turkey has a population close to 70 million that increases by an estimated 1.3% annually. Approximately 1/3 of the population is under 18 and close to 70% lives in urban areas. Other factors include a growing tourism industry, changing consumption patterns and a developing economy.

Total production capacity of the Turkish beer industry is approximately 12 million hectolitres. The total capacity of our 5 breweries in Turkey represents 74% of the total Turkish brewing capacity. Meanwhile, the capacities of our malt production facilities represent 72% of the Turkish malt production capacity of 135,000 tons.

With 5 breweries, 2 malteries and 1 hops processing facility located throughout Turkey, this company is the leading brewer in Turkey with 79% market share as of 2004.

9.1 million hectoliters of total annual brewing and 100,000 tons of annual malting capacity provide them with an unsurpassed logistic advantage in Turkey.

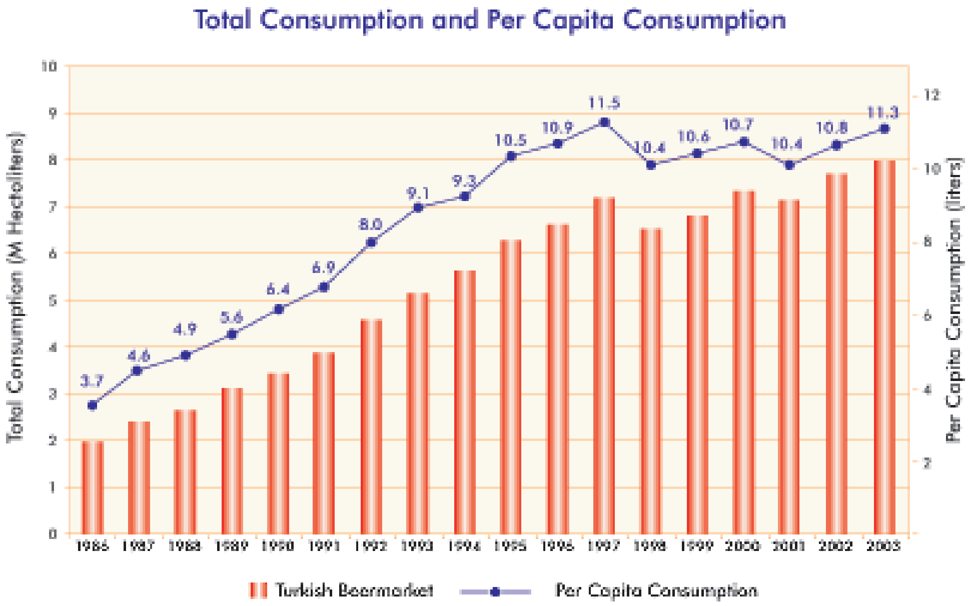


Figure 6.2 Total consumption and per capita consumption

6.2 Description of the Brewing Processes

- Production processes
- Beer types
- Utilities
- Business processes

6.2.1 Production Processes

The raw materials for beer generally include barley malt, adjuncts, hops, water and yeast (Anonym, 2002).

Production methods will differ from brewery to brewery as well as according to beer types, brewery equipment and national legislation. The main processes will, however, be the same:

- Wort production
- Fermentation / Beer processing
- Packaging

6.2.1.1 Wort Production

Process Summary

Malt is delivered to the brewery, weighed, conveyed, cleaned, stored and made available for wort production.

After milling of the malt and preliminary treatment of the adjuncts to facilitate the extraction, the malt and adjuncts are mixed with brewing water to form a mash. Adjuncts are a supplementary carbohydrate supply added either to the mash kettle as starch (e.g. maize grits or rice) or alternatively to the wort kettle as sucrose or glucose / maltose syrup. The mash is heated following a pre-set time - temperature programme, in order to convert and dissolve substances from the malt and the adjuncts in the brewing water.

Extraction is accomplished through a combination of simple dissolution and the influence of the natural enzymes formed during the malting. The substances dissolved in the water are collectively called the "extract". The solution of extract and water is called the "wort".

When the mashing is completed the insoluble solids, called the "brewers grains", are separated from the wort by straining. The brewers grains can be used as cattle feed.

The wort is boiled with hops and hop extracts releasing bitter substances and oils, which are dissolved in the wort. During boiling a precipitate consisting mainly of proteins is obtained (the "trub") and the bitter substances are isomerised which increases their solubility and. After separation of the trub, the finished wort is cooled to approx. 8-20 ^{o}C depending on the yeast strain in question and the fermentation process chosen. The cooled wort is hereafter transferred to the fermentation area.

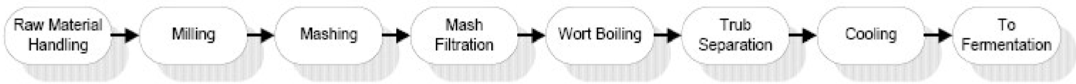


Figure 6.3 Wort Production

6.2.1.2 Fermentation / Beer Processing Area

Process Summary

The cold wort is aerated and "pitched", i. e. yeast is added. Oxygen (air) is necessary to support development of the yeast to a state and amount capable of fermenting wort efficiently. Fermentation is an anaerobic process; the yeast metabolises the fermentable carbohydrates in the wort forming alcohol and carbon dioxide. A large number of different compounds, such as higher alcohols, esters, aldehydes, etc., influencing the aroma and taste of the beer, are also produced.

When the so-called main fermentation is completed and the yeast has been "harvested", the green beer "matures" at lower temperatures. At this stage, the yeast decomposes certain undesirable constituents of the green beer, the beer is enriched with carbon dioxide, the residual extract is fermented and yeast and other precipitates settle.

However, the fine clarity expected by the consumer from most beer types is still missing. This is achieved by filtering the beer. Kieselguhr is used as filtration aid in most cases. During filtering, yeast cells still contained in the beer and other substances causing turbidity and any bacteria that might cause the beer to spoil, are removed. The filtered beer is pumped to the so-called bright beer tanks.

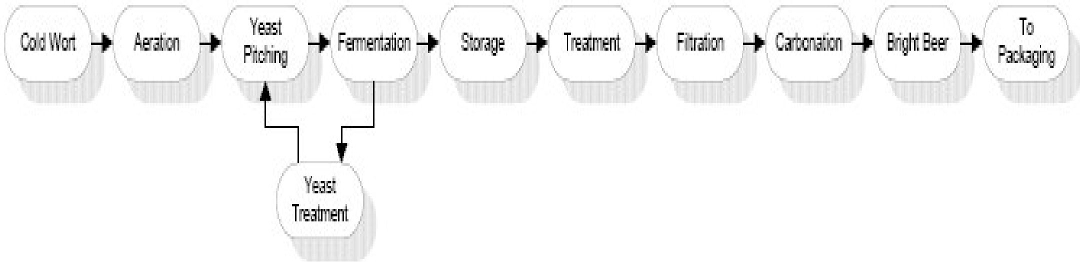


Figure 6.4 Fermentation / Beer Processing

Fermentation

Fermentation can be preceded by separation of the cold break – consisting mainly of protein – formed during cooling of the wort. The separation is performed by wort sedimentation in kettles, flotation, centrifugation or filtration.

During the subsequent so-called “pitching“ phase, sterile air or O_2 is blown into the clarified wort and the yeast is added.

Aeration is used to ensure that the yeast is supplied with an adequate amount of oxygen in order to support cell multiplication. Later on, the metabolism of the yeast changes from respiration to alcoholic fermentation; it then processes the carbohydrate molecules contained in the wort to produce ethanol and carbon dioxide. Other ingredients of the wort are also converted. The resulting fermentation products significantly influence the character of the beer produced. The duration and course of the fermentation are determined by the yeast strain and by controlling the process via the parameters pressure and temperature.

Yeast strains are divided into two major groups - top and bottom fermenting yeast. Top fermenting yeast rises to the surface during fermentation, bottom fermenting yeast settles at the bottom at the end of fermentation. Furthermore, top and bottom fermenting yeast differ with regard to fermentation temperature. Fermentation with bottom fermenting yeast is normally performed between 8 and 15°C. In the case of top fermenting yeast 15 and 25°C is used. Top fermenting yeast produces many esters that can give the beer a typically fruity and floral flavour.

Fermentation takes place in horizontal tanks or cylindro-conical tanks (CCTs). CCTs may be installed indoors or outdoors. The CO_2 produced during the fermentation process can be collected by a CO_2 recovery system.

Heat is generated during fermentation. To maintain the desired fermentation temperature, the fermentation tanks must therefore be cooled. Refrigerants used for indirect cooling are alcohol / water, glycol, ice water or brine. The refrigerant for direct cooling is NH_3.

Once fermentation has taken place, the yeast is harvested and pumped to the yeast storage tanks. During the fermentation, yeast is produced in excess. A part of this yeast is reused for a new batch of wort, the remainder being disposed of or treated as a co-product. The production yeast may be reused several times (perhaps more than ten generations), but may be replaced due to contamination.

6.2.1.3 Packaging

Process Summary

From the bright beer tanks the beer is pumped to the packaging area where it is bottled, canned or kegged.

During this final operation it is important that:

• the beer is prevented from getting into contact with oxygen;
• no carbon dioxide is lost as the beer was carbonated to specifications during beer processing

Packaging lines may be equipped quite differently, not only with respect to packaging material but also with respect to the level of automation and inspection.

Returnable bottles require thorough cleaning. The bottle washer consumes large quantities of energy, water and caustic. Furthermore, substantial quantities of wastewater are discharged. The use of non-returnable packaging material reduces the consumption of energy, water and caustic, therefore reducing wastewater generation.

In packaging lines using non-returnable bottles and cans, the bottles / cans are only flushed with water before filling. Alternatively, compressed air is used to blow out any dust particles.

If kegs are used, they are cleaned and sterilised with steam before filling.

Below the most important functions of the packaging lines for returnable / non-returnable bottles, cans and kegs are shown and described.

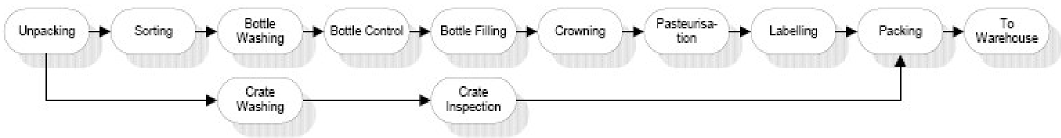


Figure 6.5 Packaging Returnable Bottles

<u>Returnable Bottles</u>

Un-packing: The bottles are lifted from the crates by gripper heads and placed on a large conveyor from where they are transported to the sorting machine.

Empty crates are transported to the crate washer.

Sorting: The returned bottles are sorted electronically. Foreign bottles are returned to their respective manufacturers or crushed and sent to recycling.

Bottle Washing: Before being filled with beer, the returned bottles are converted to a bottle washer that cleans the bottles both inside and outside. Inside the bottle impurities include residual beer mould, cigarette butts, organic solvents, etc. Outside impurities may include labels, aluminium foil and dust particles.

Bottle washing is likely to consist of soaking, rinsing, sterilisation and re-rinsing. To improve the cleaning effect surfactants, complexation agents and similar agents are added to the cleaning solution. In order to guarantee the hygienic condition of the bottles, disinfectants may be added in the rinsing zones of the bottle-cleaning machine.

Bottle Control: When a bottle has been cleaned, it is inspected for damage or residual dirt. The systems used to detect such undesirable bottles are named EBI (Empty Bottle Inspection). Bottles that are dirty but sound are returned to the bottle washer while broken bottles are collected and recycled.

Bottle Filling: The bottles are transported on conveyor belts from the bottle washer to the filling machine. They are filled (on circular continuous systems with short- or long-tube fillers having mechanically, pneumatically or electronically controlled valves) under pressure according to the quantity of dissolved carbon dioxide in the beer.

In addition to filling bottles, the most important function of the filling machine (which may have various forms) is to prevent oxygen coming into contact with the beer.

The bottles are evacuated and counterpressurised with CO_2 before the actual filling of beer.

Crowning: The bottles are closed up immediately after filling (usually with crown corks) and the filling volume is checked. Furthermore, the presence of crown cork is checked. The sealed bottles can then be conveyed to the tunnel pasteuriser. Bottles that are sorted out are emptied and returned to the bottle washer.

Pasteurisation: If the beer has not been sterile filtered, the beer might be pasteurised to prolong shelf life. It is important that all micro-organisms capable of growing in the beer are destroyed. Pasteurisation guarantees practically unlimited biological stability.

Two different methods are used for the pasteurisation:

a) tunnel pasteurisation, during which the beer is pasteurised in bottles (or cans), i.e. beer and bottle is pasteurised as a closed unit

b) flash pasteurisation, employing a heat exchanger in which the beer is pasteurised before it is filled into bottles (or kegs).

Labelling: Following tunnel pasteurisation, the bottles are conveyed to the labeller. The design possibilities are virtually unlimited with labels on the body, back and neck, bands, bows, foils, etc. Glues (e.g. starch- or protein-based) are used as adhesives so that the labels come off easily when the returnable bottles are cleaned. To guarantee optimal removal of the old labels in the bottle washing machine, special, high wet strength label paper can be used.

Packing: The bottles are packed in crates, cartons or other forms of transport packaging and palletised.

Crate Washing / Inspection: The crates are washed with water and inspected for damages, colour, logo, etc. Sound and correct crates are sent to the packaging machine.

Non –Returnable Bottles:

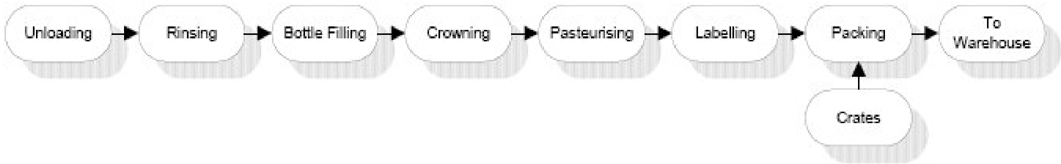


Figure 6.6 Packaging Non-returnable Bottles

For packaging lines using non-returnable bottles the phases are the same as described for the returnable bottles - from filling of the bottles and onwards. However, the first steps are different for non-returnable bottles as the bottles are not delivered in crates, washed and sorted. Instead the following two activities which are similar to the ones for cans take place:

Unloading: Non-returnable bottles are delivered on pallets from the glassworks. The bottles are pushed off the pallets in layers onto a reception table / conveyor chain. When a layer has been pushed off, the spacer packaging is removed and returned to the manufacturer.

Rinsing: The bottles arrive clean from the glassworks but dust can get into the bottles during transport. Therefore, the bottles are rinsed before filling either by spraying with water or the dust is blown out with compressed air. For rinsing the bottles are turned so that their openings face downwards and they are then turned upright again before filling.

Cans:

Figure 6.7 Packaging Cans

Unloading: Cans are supplied in bulk as so-called tall packs. The cans are pushed off the pallet in layers onto a conveyor chain. When a layer has been pushed off, the spacer packaging is removed and returned to the manufacturer.

Marking: The latest sales date is usually marked on the bottom of the cans. Since the cans are wet all over, later marking with the shelf life date and other information is performed while the cans are still dry.

Rinsing: The cans arrive clean from the manufacturer, but dust can get into the cans during transport. Therefore, the cans are rinsed before filling either by spraying with water or the dust is blown out with compressed air. For rinsing the cans are turned so that their openings face downwards and they are then turned the right way up again before filling.

Can filling: Filling of cans is based on the same principles as short-tube bottle filling. Because of their low weight it is necessary to convey the cans gently to ensure a constant spacing. The cans are separated on special pocket chains and placed on the can conveyor. Furthermore, special attention shall be paid to the thin wall thickness and thereby low stability of the cans.

Sealing: The cans are sealed with lids immediately after filling and as for the bottles the filling height is checked. Sealing of cans is a two step operation (pressing first with a pre-roller and secondly with a seaming roller) that shall be performed exactly right to prevent pressure loss and thus beer spoilage.

Pasteurisation: The cans may then be pasteurised. The same principles apply to can pasteurisation as to bottle pasteurisation but as the cans transfer heat better than glass the process proceeds more quickly.

Kegs:

Figure 6.8 Packaging Kegs

Depalletising / Palletising: Kegs are transported on pallets. The depalletising / palletising is usually performed layer by layer by pushing the kegs together and displacing or lifting the layer by pneumatically operated grippers.

Decapping: The caps that protect the spear (fitting for cleaning, filling, emptying and closing of the kegs) from dirt during transport and storage must be removed before the kegs are cleaned and refilled.

Inversion: Before filling the empty kegs must be arranged with the fittings at the bottom. The inverting device, therefore, rotates kegs that are not upside down 180°.

Pressure Testing: Kegs are always under pressure. If the pressure is below a certain limit, the spear is not sealed. In this case the keg is ejected for repair.

External Cleaning: Pre-soaking, cleaning and rinsing clean the outside of the keg. The cleaning solution is recirculated.

Internal Cleaning and Filling: Internal cleaning and filling of kegs is performed in many stages in one or more filling streets. First the kegs are cleaned with water and caustic and sterilised with steam. Afterwards the kegs are pressurised and filled with beer. Before discharge the head is rinsed. Weighing of the kegs controls the filling volume.

Capping: Protective plastic caps are put on the fittings.

Warehouse: Packed beer is stored in the warehouse. It is important to store bottled beer inside as sunlight destroys the beer quality.

Warehouse for glass bottles situated in a cold climate should be heated in order to prevent bottle breakage.

6.2.2 Beer Types

Different beer types are produced which differ from one another in taste, colour, aroma, mouth feel, foam, etc. Parameters influencing the wide spectrum of beer types are choice of brewing materials, yeast strain and production methods.

In order to produce different types of beers, portions of various malts and adjuncts must be used. Pilsner malt is the most commonly used malt type. Other malts in question may be dark malt (Munich malt), crystal malt, black malt, wheat malt, etc. Malt may be supplemented by adjuncts. Adjuncts may be maize, rice, barley, wheat, sugar, etc. depending on region.

The choice of yeast strain has a large influence on the flavour of the beer. Yeast strains are divided into two major groups – top and bottom fermenting yeast. Top fermenting yeast strains typically produce beer with a more fruity and floral flavour than bottom fermenting yeast strains. In rare cases bacteria, e.g. lactic acid bacteria, may be used to ferment the beer.

Most beer types can be produced using the methods described earlier. However, for some products the production method may vary on one or more points. Examples are: Addition of fresh wort before secondary fermentation; Ice beer production; Nitrogen may be used when dispensing draught beer (or in cans with widgets) giving a very persistent foam; Alcohol-free beer may be produced by suppression of alcoholic fermentation or removal of alcohol.

6.2.3 Utilities

To run a brewery, as in other industries, utility installations are necessary. These comprise:

- Boiler plant
- Cooling plant
- Water treatment plant
- CO_2 recovery plant
- Nitrogen generation
- Compressed air plant
- Electricity supply

6.2.4 Business Processes

Sourcing: The purchasing function is important when controlling the environmental impact from breweries.

Purchasing normally includes:

- Selection of supplier
- Choice of quality
- Arrangements for delivery including packaging size and material
- Return of packaging material

Examples of environmental topics related to sourcing is the purchase of fuels with a minimum sulphur content and malt with a minimum content of dust, stones and broken grains.

Quality and Environmental Assurance / Control: A laboratory is necessary to perform quality and environmental control. Brewery laboratories vary considerably from brewery to brewery. Well- equipped laboratories provide quality control checks on all aspects of raw material control and use, brewing, fermentation, storage filtration and packaging. In addition, they can analyse consumer product samples, process water, cleaning water, effectiveness of cleaning procedures, wastewater, etc. on a routine basis.

Product quality is closely connected to the environment. Breweries will not compromise on product quality meaning that a good product quality will reduce the breweries' impact on the environment. In addition, the quality control will supply data on which the environmental management can be based.

Production Planning: Planning is an important tool in controlling the environmental impact from breweries. Proper production planning will increase the productivity resulting in less resources needed, e.g. reduction in product changes on the packaging lines will result in less chasing water being used.

Information Technologies: Breweries have always highlighted parameters such as extract utilisation, loss, etc. Higher extract utilisation and less loss will reduce the breweries' impact on the environment. In order to be able to supply these data fast and efficiently to the decision makers information technology will be the tool in the future for the integration of production quality and environmental information in management systems.

Human Resources: Training is important in order to improve the employees' awareness in relation to quality and environmental issues.

Training and awareness programmes for new and old employees and temporaries are an integrated element for many breweries and represent an opportunity to include environmental training.

6.3 Environmental Impact

The major public concern of breweries has traditionally been about waste- water pollution from untreated discharges. Locally, the odour and the noise from the operation have caused public concern.

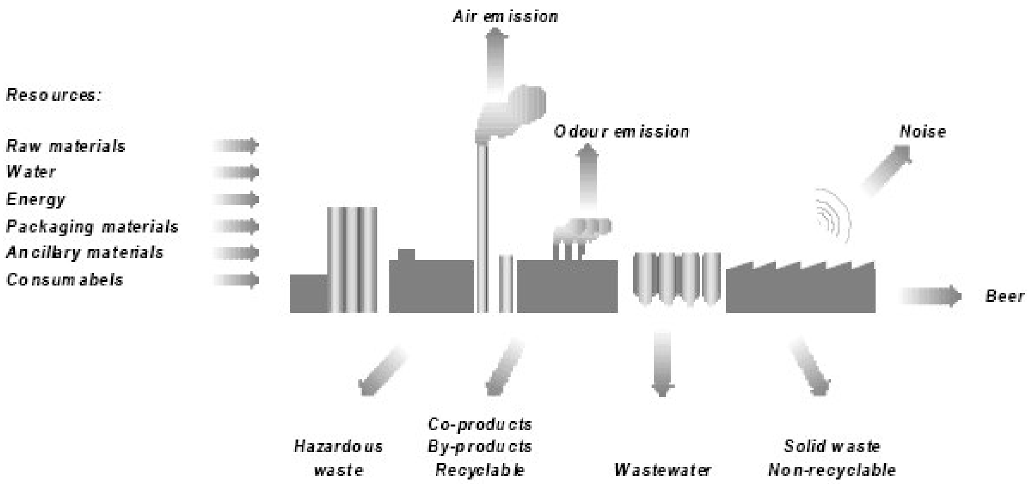


Figure 6.9 Environmental impact from a brewery

The environmental impact from breweries is shown in the figure above and can be divided into 3 groups: resource availability, nuisances and toxic effects.

The resource utilisation is an issue which should be seen from a sustainable development perspective, scarcity of water resources, combustion of fossil fuels, utilisation of raw materials, emission of ozone depletion chemicals, CO_2, etc.

Compared to other types of industries the utilisation of resources is the most characteristic environmental impact from breweries. This means that optimisation of the resource utilisation will result in reduced environmental impact and operational costs.

The nuisance impact is typically felt by the neighbours of a brewery and is related to the emission of noise, odour (even in cases of high acceptance rates) and dust mainly from handling malt and adjuncts.

Reduction of the nuisance impact will often result in additional costs and is to some extent coupled with occupational health measures.

The toxic effect is more diverse as it covers the toxic impact from un- controlled products or chemical spills into e. g. rivers and wastewater treatment plants.

Potential toxic impact from breweries is often related to the evaluation of purchased goods and the contingency measures employed in order to reduce the effects of accidents.

6.3.1 Geographical Impact

The environmental impact by beer production is dealt with seen separately from a global, regional and a local perspective.

6.3.1.1 Global

From a global perspective, the environmental impact is primarily related to the breweries' consumption of energy generated from fossil fuels such as natural gas, oil and coal. In this relation it is emphasised that not only the actual energy consumption (in MJ) is considered, but also the environmental effects of compounds in the fuel and the combustion residuals such as the emission of CO_2, SO_2 and NO_x in the flue gasses.

It should, however, be noted that the CO_2 emission from the fermentation process is not relevant as it concerns short cycle CO_2. In this cycle CO_2 is taken up from the atmosphere by the barley plants and during the fermentation process released again.

6.3.1.2 Regional

From a regional perspective, 3 subjects of concern are identified, i.e. water, wastewater and solid waste.

The actual water consumption of a brewery may have an impact on the exploitation of the available water sources. Overexploitation of water resources can have effects such as deterioration of the water recipients and the quality of the water itself.

In addition previous and existing handling of fuel oil, other oil products, chemicals and lubricants may constitute a risk for pollution of surface and ground water.

Untreated brewery wastewater discharged in surface waters can bring about a rapid deterioration of their physical, chemical and biological qualities. Their decomposition depletes the dissolved oxygen in the water that is vital for aquatic life. Release of nitrogenous and phosphorous compounds in the wastewater will stimulate aquatic plant growth contributing to eutrophication of water bodies. Further, due to turbidity and colour photosynthesis may be restricted and thereby affecting the primary link in the food chain.

However, within the EU, the discharge of untreated wastewater will cease by the implementation of EU Directive 98/15/EEC on urban wastewater treat- ment. This means that brewery wastewater has to be treated either by a brew- ery owned plant or by third parties, e.g. public wastewater treatment plants. The environmental impact of wastewater discharge is then reduced to the effects from the energy consumption, solid waste generation and the treatment efficiency of the wastewater treatment plant.

Generation of solid waste that cannot be reused or recycled requires disposal at a landfill even after possible utilisation of the energy in an incinerator. Available landfill area is a very limited resource within Europe.

For the hazardous waste which is regulated according to EU directive 2000/532/EC, special handling and disposal schemes must be followed. However, the hazardous waste generation in breweries is in general limited to spent laboratory chemicals.

6.3.1.3 Local

From the local perspective 3 subjects of nuisance are identified: i.e. noise, odour and dust. In addition, the local surrounding may suffer an environmental impact due to risk activities.

Excessive noise may cause problems in the surrounding society, especially noise during the night. Noise from breweries comes from transport to and from the brewery, internal transport and noise from stationary sources such as cooling towers, conveyers and ventilation.

For a brewery the odour is not noxious. The odour mainly comes from the wort boiling and has a bread-like smell. Fermentation, bottle washers, by- product storage tanks, silos and wastewater treatment plants are other possible odour sources.

Dust emission generated mainly through raw material conveying and kieselguhr handling can cause local problems.

The risk activities in a brewery are associated with dust explosions from conveying and handling the raw materials, fire especially in connection with storage of fuel oils and the release of NH3 from the cooling plant. Accidents caused by either of these activities may cause damage to the local environment. The activities are, however, regulated under local safety statutory orders.

6.3.1.4 General

As a subject with relevance to the environmental impact for all three geographical areas is the utilisation of raw materials identified.

The reason for this is the effect which poor utilisation of raw materials has on the environmental impacts. Loss of beer at a late stage in the production will, therefore, also imply unnecessary energy and water consumption, wastewater discharge, solid waste generation, and nuisance for the local surroundings.

6.4 Solid Waste Generation

Solid materials enter the brewery in the form of raw and ancillary materials. The solid material leaves the brewery as co-products (brewers grains and surplus yeast), primary and secondary packaging material, solid waste and hazardous waste.

The hazardous waste is regulated by EU Directive 2000/532/EC and has to be handled according to the legal requirements. In general a very small amount of hazardous waste is produced, e.g. spent laboratory chemicals and batteries.

Major co-, by-product and solid waste fractions are identified by the following example:

The generation of co-, by-products and solid waste is quantified for a 1 mill. hl/year brewery producing mainly returnable bottles in plastic crates and without generation of flue gas and wastewater treatment residuals.

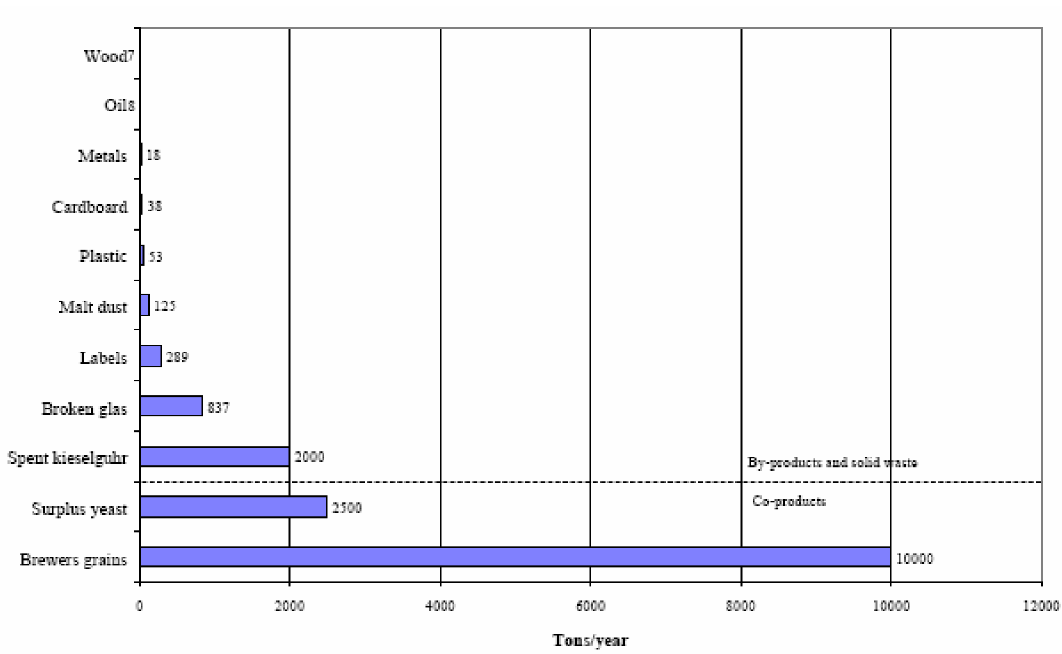


Figure 6.10 Example of co-, by-product and solid waste quantities from a brewery

Residual streams from breweries may be divided into:

• Co-products linked to the production process
• By-products and recyclable
• Non-recyclable (solid waste)

The co and by-products are in general useful and many different applications have been reported:

• Malt dust. Animal fodder, mixing into brewers grains, utilisation in the production.
• Brewers grains. Animal fodder, including trub from the whirlpool.
• Surplus yeast. Animal fodder, yeast pills, cosmetics, pharmaceutical industry, spreads.

As shown in the figure 6.10 it is important to ensure a reliable use of the major co- and by-products, brewers grains and surplus yeast.

Recyclable waste examples from breweries are:

• Spent kieselguhr from the beer filtration that could be used in the cement industry.
• Broken glass from the packaging lines that can be re-used for glass manufacturing.
• Label pulp from the washing of returnable bottles that can be re-used in paper manufacturing.
• Plastic from supply of ancillary materials, wrapping of products, etc. that can be recycled.
• Cardboard and paper from the supply of ancillary materials that can be re- used by paper factories pending upon the pulp quality.
• Metal from hop cans, replacement of equipment, etc. that can be melted and used in the metal industry.

Through source separation the brewery strives to increase the ratio of recyclable waste.

The main reasons for large solid waste generations shall therefore be found in the organisation of the co-product handling, by-product disposal and the options for disposal of recyclable materials.

CHAPTER SEVEN
MATERIAL & METHOD

7.1 General Information

In the thesis concepts are investigation of the beer industry. At the beer industry contains several units for production as shown in figure 7.1. These process units are briefly described in the previous chapter (chapter 6). Operations and amount of production of the solid wastes are investigated and minimization techniques and recyclable amounts for this wastes are calculated to their costs analysis.

Solid waste management is the generation, separation, collection, transfer, transportation and disposal of waste in a way that takes into account different parameters, such as public health, economics, environment, conservation aesthetics and is responsive to public demands. In the scope of this thesis, the type and amount of wastes which were produced in the brewing industry were specified, the sources of wastes were detected and it is analyzed that in which production unit wastes were produced.

A solid waste management system was tried to be applied through these datas. In this solid waste management system, it is tried to minimize the wastes at their sources. Recommendations and strategies were done in order to maximize the recycling and minimize the wastes.

As analyzed in the previous chapters solid wastes are separated into two groups, residential and industrial wastes. The statistics about these wastes are realized by the SIS. The State Institute of Statistics (SIS), the centralized system for Turkey's official statistics has infrastructure for compilation, evaluation, analysis and publication of statistical data concerning the economic, social and environmental structure of the country.

According to the results of the survey done by SIS, municipal solid waste were collected in 3011 municipalities out of 3215. In the 3011 municipalities receiving solid waste services, 12.8 million tones in summer, 13.3 million tones in winter and as a total 26.1 million tones of solid waste were collected in 2003.

8.6 % of the total manufacturing industry waste (17.06 million tons) was recycled or reused, 34.68 % was sold or donated and 56.76% was disposed of.

It was stated that, 57 % of the total amount of solid waste generated, was disposed of. This amount is 9.7 million tons.

Data on hazardous waste can be available for the year 2000. According to the results of the 2000 Manufacturing Industry Waste Survey, 1.308 million tons/year hazardous waste was generated in 2000 from manufacturing industry. 10.84 % of total amount was recycled in the establishment field. 26.25 % was sold and donated and 62.91 % of it was disposed off.

The wastes which were produced in the factory that is analyzed in the concept of the thesis are 7% nylon, 19% paper/cardboard, 56% deposit bottle, 6% one way bottle and 12% plastic.

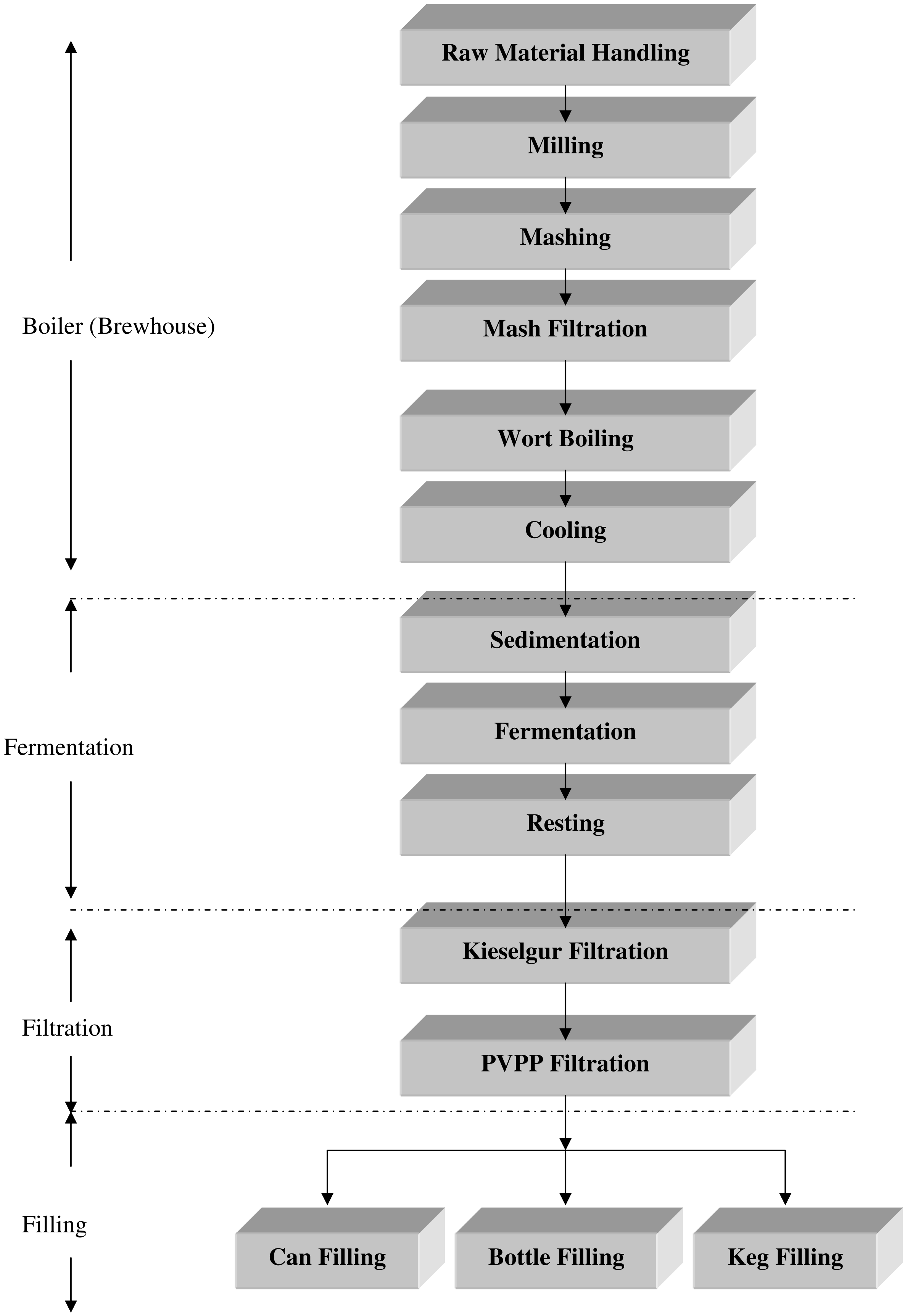


Figure 7.1 Beer Production Processes

7.2 Fabric Wastes

In brewing industry, 80% of solid wastes are caused by filling unites, 20% of solid wastes are caused by production units. Beer production process figure 7.1 is shown above. Generally if we sort the wastes on department basis;

Department of Filling:

- Bottle Label, Bottle Cover, box cover
- Stainless Steel Material
- Aluminum
- Plastic Bottle Case
- Glass Bottle (brown, green, white)
- Bottle Label
- Track

Department of Offices:

- Paper
- Cardboard
- Printer Cartridge
- Nylon
- Battery

Department of Electric Maintenance :

- Stainless Steel Material
- Iron Material
- Aluminum Material
- Copper Material
- Grease Cup

Department of Production:

- Kieselgur Sack (Bag)
- Lactic Acid Case

- Cardboard
- Pulp
- Aluminum
- Hop
- Malt

Department of Mechanical Maintenance :

- Grease Cup
- Dye Vessel
- Stainless Steel Material
- Iron Material
- Aluminum Material
- Copper Material
- Brass Material
- Metal Excelsior
- Oil Filter
- Asbestos Material

Department of Energy :

- Lime Sack
- CO2 Tube
- Stainless Steel Material
- Plastic
- Iron Material
- Aluminum Material
- Copper Material

7.3 ÇEVKO

In November 1991, fourteen leading packaging, beverage and detergents companies founded ÇEVKO in order to contribute and to play a leading role in the establishment of Packaging Waste Recovery System in Turkey. ÇEVKO considers as mission the protection of the environmental values in accordance with the principle of "sustainable development". Conserving natural resources, saving energy and reducing pollution are the major benefits of recycling the packaging materials. ÇEVKO (Environmental Protection and Packaging Waste Recovery and Recycling Trust) helps protect the environment through maximizing the efficiency of solid waste recovery and recycling systems.

The regulations and experiences of the European Union, the principles of integrated waste management, which is based on shared responsibility, define the guidelines of ÇEVKO activities. According to the principles of shared responsibility, the participants as consumers, economic operators, local authorities and recycling industry are the key collaborators of ÇEVKO for the establishment of an integrated waste management system. ÇEVKO has been working closely with these key participants since 1991. On March 31, 2005, Turkish Ministry of Environment and Forestry has designated ÇEVKO as the "Authorized Recovery Organization" according to the Regulation on the Control of Packaging and Packaging Waste (Turkish Ministry of Environment and Forestry, 2006).

The unit prices defined by ÇEVKO for packing waste in 2006:

- Glass: 7.60 YTL/ton
- PET: 79.08 YTL/ton
- Plastic except PET: 45.36 YTL/ton
- Aluminum: 54.60 YTL/ton
- Steel: 19.08 YTL/ton
- Paper/Cardboard: 10.80 YTL/ton
- Composite: 126.00 YTL/ton
- Local administration support: 3000 YTL

This factory is giving the packing wastes which are formed in production process to CEVKO which is the authorized institute by Turkish Ministry of Environment and Forestry**.** These factories delegates the authority about collecting the packing wastes, reaching recycling targets and preparing “Waste Management Plan” to CEVKO via paying Green Dot fee.

At 30.07.2004, it is started to apply the regulation for controlling packing and packing wastes. Starting with this date, the factories are responsible for recycling the 60% wastes in weight within 10 years. According to this regulation the recycling targets are shown as table 7.1;

Table 7.1 Recycling Ratios (%)

	Recycling Ratios (%)									
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Glass	32	35	37	40	43	45	48	52	56	60
Plastic	32	35	37	40	43	45	48	52	56	60
Metal	30	33	35	38	42	45	48	52	56	60
Paper/cardboard	20	30	35	38	42	45	48	52	56	60

7.4 Cost Analysis

Purchasing prices of materials in brewing industry:

- Glass: 22 YKR/bottle
- Plastic: 1.7 USD/kg
- Paper/Cardboard: 0.104 YTL/piece
- Aluminum: 89.1 USD/1000 can

⇨ Glass = 22 YKR/bottle   1 bottle ≈ 250 gr

Glass = 22 YKR/250 gr ⇨ 1 ton glass = 880 YTL

⇨ Plastic = 1.7 $/kg ≈ 2.7 YTL/kg

1 ton plastic = 2700 YTL

⇨ Paper/Cardboard = 0.104 YTL/grain

1 grain = 250 gr 1 ton Paper/Cardboard = 416 YTL

Amounts of wastes of deposit glass bottles between 2002 and 2005 can be seen in table 7.2.

Table 7.2 Amounts of wastes of deposit glass bottles

DEPOSIT GLASS BOTTLE														
		JAN.	**FEB.**	**MAR.**	**APR.**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT.**	**OCT.**	**NOV.**	**DEC.**	**TOTAL**
2002	HL	94.942	106.449	152.489	156.019	172.329	173.852	185.559	187.020	167.787	141.996	33.530	119.675	1.691.647
2002	KG	24.500	12.600	86.580	48.520	81.260	126.620	87.400	48.620	83.040	58.160	24.220	51.920	**733.440**
2002	***KG/HL***	***0,26***	***0,12***	***0,57***	***0,31***	***0,47***	***0,73***	***0,47***	***0,26***	***0,49***	***0,41***	***0,72***	***0,43***	
2003	HL	141.873	100.438	166.121	149.303	186.730	198.232	200.004	201.127	170.535	124.846	54.427	113.997	1.807.633
2003	KG	27.400	22.470	68.420	17.000	79.120	76.500	66.020	82.880	87.540	39.260	29.560	49.900	**646.070**
2003	***KG/HL***	***0,19***	***0,22***	***0,41***	***0,11***	***0,42***	***0,39***	***0,33***	***0,41***	***0,51***	***0,31***	***0,54***	***0,44***	
2004	HL	135.953	125.284	184.340	176.480	178.085	186.032	188.933	200.417	162.148	70.671	90.293	171.474	1.870.110
2004	KG	27.960	35.200	76.860	89.140	115.460	70.480	113.420	99.740	88.960	17.960	59.300	64.240	**858.720**
2004	***KG/HL***	***0,21***	***0,28***	***0,42***	***0,51***	***0,65***	***0,38***	***0,60***	***0,50***	***0,55***	***0,25***	***0,66***	***0,37***	
2005	HL	111.734	147.469	158.510	178.361	200.060	175.681	192.862	192.407	163.577	61.829	107.520	156.509	1.846.519
2005	KG	0	93.960	52.510	60.620	114.180	88.210	109.920	112.050	111.770	103.720	74.920	117.540	**1.039.400**
2005	***KG/HL***	***0***	***0,64***	***0,33***	***0,34***	***0,57***	***0,50***	***0,57***	***0,58***	***0,68***	***1,68***	***0,70***	***0,75***	
2006	HL	101.033	144.397	141.510										386.940
2006	KG	60.140	102.940	115.430										**278.510**
2006	***KG/HL***	***0,60***	***0,71***	***0,82***										

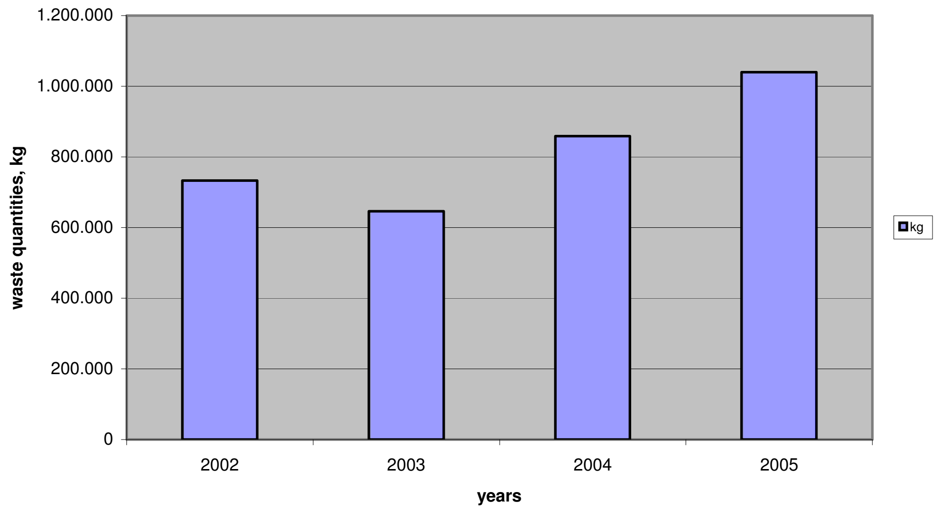


Figure 7.2 Annual quantities of deposit bottle

Most common waste in a beer factory is the glass waste. Glass wastes are comprised of two parts, deposit glass wastes and one-way glass wastes. Because of the fact that there is more demand for beer glasses with deposit , the amount of production of glass with deposit is much more higher than production of one way glasses. Therefore the amount of wastes are different from themselves. Annual quantities of deposit bottle are indicated in figure 7.2 and also annual costs of deposit bottle are shown in figure 7.3.

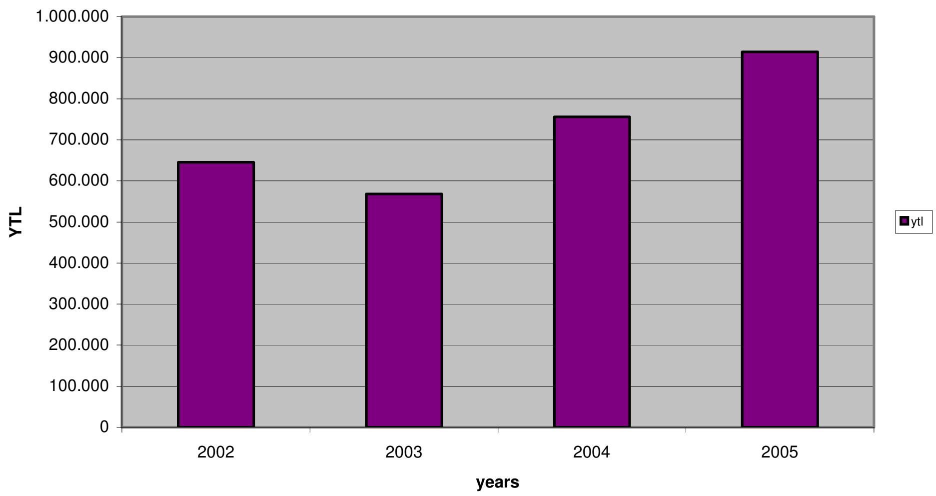


Figure 7.3 Annual costs of deposit bottle

Table 7.3 Amounts of wastes of one way bottles

ONE WAY BOTTLE														
		JAN.	**FEB.**	**MAR.**	**APR.**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT.**	**OCT.**	**NOV.**	**DEC.**	**TOTAL**
2002	HL	94.942	106.449	152.489	156.019	172.329	173.852	185.559	187.020	167.787	141.996	33.530	119.675	1.691.647
2002	KG	4.180	0	6.320	3.300	7.600	12.080	9.160	12.080	7.800	12.360	3.640	2.500	**81.020**
2002	***KG/HL***	***0,04***	***0,00***	***0,04***	***0,02***	***0,04***	***0,07***	***0,05***	***0,06***	***0,05***	***0,09***	***0,11***	***0,02***	
2003	HL	141.873	100.438	166.121	149.303	186.730	198.232	200.004	201.127	170.535	124.846	54.427	113.997	1.807.633
2003	KG	3.820	2.960	38.320	8.940	5.960	3.640	13.380	5.240	3.020	13.080	12.980	2.680	**114.020**
2003	***KG/HL***	***0,03***	***0,03***	***0,23***	***0,06***	***0,03***	***0,02***	***0,07***	***0,03***	***0,02***	***0,10***	***0,24***	***0,02***	
2004	HL	135.953	125.284	184.340	176.480	178.085	186.032	188.933	200.417	162.148	70.671	90.293	171.474	1.870.110
2004	KG	3.160	0	7.020	4.600	3.580	3.660	2.340	28.280	0	2.200	0	6.240	**61.080**
2004	***KG/HL***	***0,02***	***0,00***	***0,04***	***0,03***	***0,02***	***0,02***	***0,01***	***0,14***	***0,00***	***0,03***	***0,00***	***0,04***	
2005	HL	111.734	147.469	158.510	178.361	200.060	175.681	192.862	192.407	163.577	61.829	107.520	156.509	1.846.519
2005	KG	0	4.220	0	3.120	2.740	0	2.250	8.480	15.380	10.660	4.000	49.020	**99.870**
2005	***KG/HL***	***0***	***0,03***	***0,00***	***0,02***	***0,01***	***0,00***	***0,01***	***0,04***	***0,09***	***0,17***	***0,04***	***0,31***	
2006	HL	101.033	144.397	141.510										386.940
2006	KG	4.320	3.220	3.640										**11.180**
2006	***KG/HL***	***0,04***	***0,02***	***0,03***										

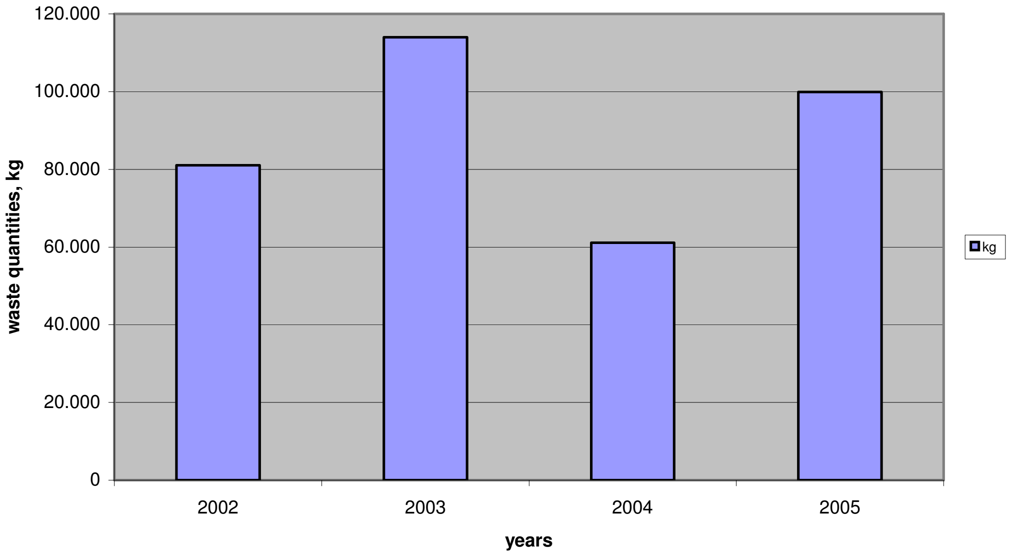


Figure 7.4 Annual quantities of one way bottle

In the charts below and above , the annual quantities of wastes of one way bottle and costs of these bottles can be seen. Amounts of wastes of plastics are shown in table 7.4.

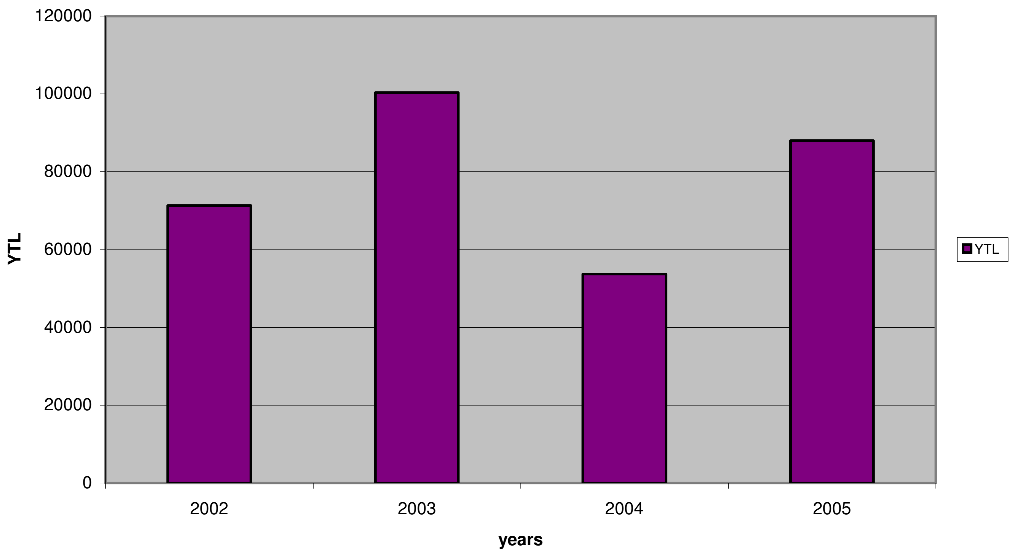


Figure 7.5 Annual costs of one way bottle

Table 7.4 Amounts of wastes of plastics

PLASTIC														
		JAN.	**FEB.**	**MAR.**	**APR.**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT.**	**OCT.**	**NOV.**	**DEC.**	**TOTAL**
2002	HL	94.942	106.449	152.489	156.019	172.329	173.852	185.559	187.020	167.787	141.996	33.530	119.675	1.691.647
2002	KG	0	0	39.680	0	0	28.060	29.300	2.280	0	31.060	22.080	0	**152.460**
2002	***KG/HL***	***0,00***	***0,00***	***0,26***	***0,00***	***0,00***	***0,16***	***0,16***	***0,01***	***0,00***	***0,22***	***0,66***	***0,00***	
2003	HL	141.873	100.438	166.121	149.303	186.730	198.232	200.004	201.127	170.535	124.846	54.427	113.997	1.807.633
2003	KG	0	11.950	14.280	0	0	29.880	36.920	0	32.440	61.080	0	15.920	**202.470**
2003	***KG/HL***	***0,00***	***0,12***	***0,09***	***0,00***	***0,00***	***0,15***	***0,18***	***0,00***	***0,19***	***0,49***	***0,00***	***0,14***	
2004	HL	135.953	125.284	184.340	176.480	178.085	186.032	188.933	200.417	162.148	70.671	90.293	171.474	1.870.110
2004	KG	14.040	0	0	72.660	0	0	77.500	1.180	0	29.840	81.520	0	**276.740**
2004	***KG/HL***	***0,10***	***0,00***	***0,00***	***0,41***	***0,00***	***0,00***	***0,41***	***0,01***	***0,00***	***0,42***	***0,90***	***0,00***	
2005	HL	111.734	147.469	158.510	178.361	200.060	175.681	192.862	192.407	163.577	61.829	107.520	156.509	1.846.519
2005	KG	0	0	0	83.840	0	0	47.500	3.010	36.940	0	0	50.720	**222.010**
2005	***KG/HL***	***0***	***0,00***	***0,00***	***0,47***	***0,00***	***0,00***	***0,25***	***0,02***	***0,23***	***0,00***	***0,00***	***0,32***	
2006	HL	101.033	144.397	141.510										386.940
2006	KG	0	0	0										**0**
2006	***KG/HL***	***0,00***	***0,00***	***0,00***										

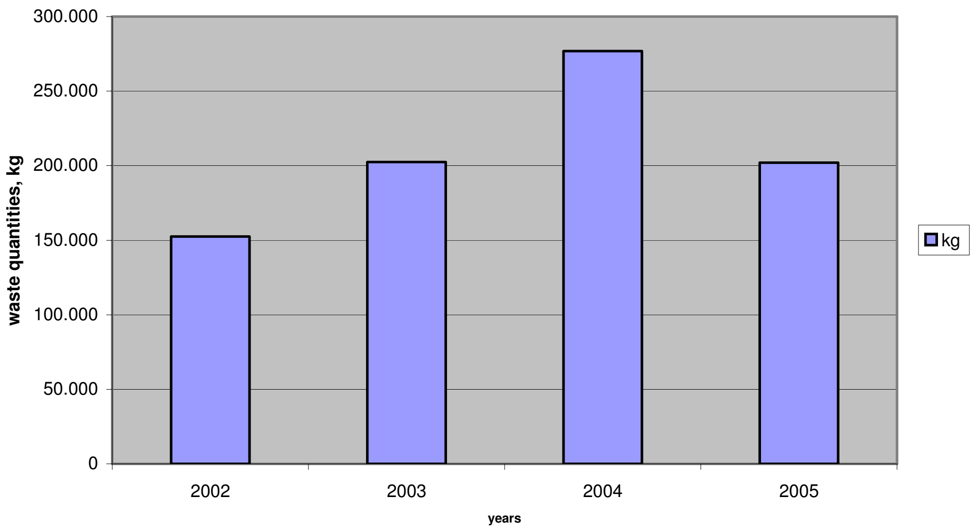


Figure 7.6 Annual quantities of plastic

As seen from the figure 7.6, there are different oscillations for formation of the plastic wastes on different times. Generally amount of plastic wastes increases during June and July when consumption of beer increases and in November and December when it is the time for New Year celebrations. The studies have been started to minimize the amount of plastic which is used during packing, packaging and transportation.

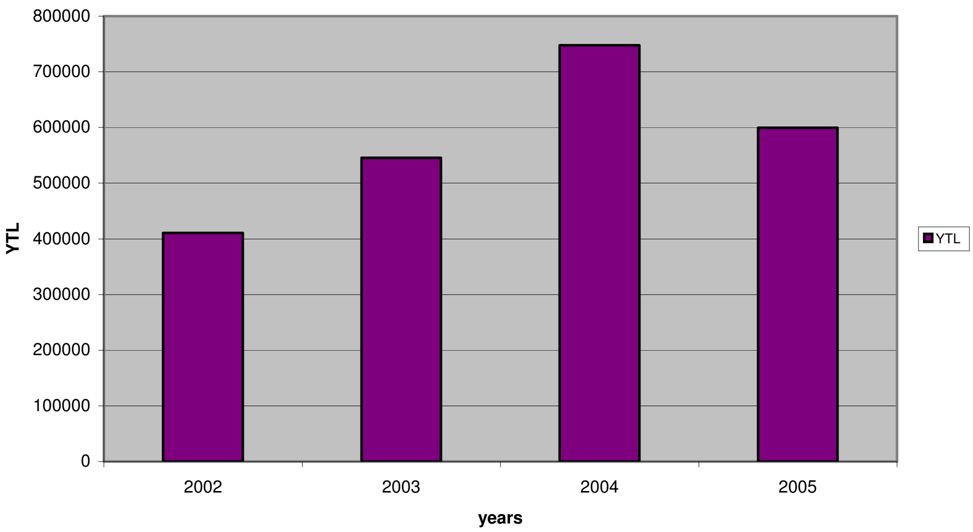


Figure 7.7 Annual costs of plastic

Table 7.5 Amounts of wastes of nylons

NYLON														
		JAN.	**FEB.**	**MAR.**	**APR.**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT.**	**OCT.**	**NOV.**	**DEC.**	**TOTAL**
2002	HL	94.942	106.449	152.489	156.019	172.329	173.852	185.559	187.020	167.787	141.996	33.530	119.675	1.691.647
2002	KG	3.700	1.840	6.300	5.080	7.600	8.720	10.120	12.080	7.800	12.360	3.640	2.500	81.740
2002	***KG/HL***	***0,04***	***0,02***	***0,04***	***0,03***	***0,04***	***0,05***	***0,05***	***0,06***	***0,05***	***0,09***	***0,11***	***0,02***	
2003	HL	141.873	100.438	166.121	149.303	186.730	198.232	200.004	201.127	170.535	124.846	54.427	113.997	1.807.633
2003	KG	4.440	4.430	4.640	5.600	4.700	7.110	8.460	5.240	3.020	13.080	12.980	2.680	76.380
2003	***KG/HL***	***0,03***	***0,04***	***0,03***	***0,04***	***0,03***	***0,04***	***0,04***	***0,03***	***0,02***	***0,1***	***0,24***	***0,02***	
2004	HL	135.953	125.284	184.340	176.480	178.085	186.032	188.933	200.417	162.148	70.671	90.293	171.474	1.870.110
2004	KG	4.160	2.246	6.196	6.240	5.180	694	5.850	28.280	0	2.200	0	6.240	67.286
2004	***KG/HL***	***0,03***	***0,02***	***0,03***	***0,04***	***0,03***	***0***	***0,03***	***0,14***	***0***	***0,03***	***0***	***0,04***	
2005	HL	111.734	147.469	158.510	178.361	200.060	175.681	192.862	192.407	163.577	61.829	107.520	156.509	1.846.519
2005	KG	2.220	6.274	4.920	6.860	9.020	7.420	7.710	8.480	15.380	10.660	4.000	49.020	131.964
2005	***KG/HL***	***0,02***	***0,04***	***0,03***	***0,04***	***0,05***	***0,04***	***0,04***	***0,04***	***0,09***	***0,17***	***0,04***	***0,31***	
2006	HL	101.033	144.397	141.510										386.940
2006	KG	2.880	5.240	6.100										14.220
2006	***KG/HL***	***0,03***	***0,04***	***0,04***										

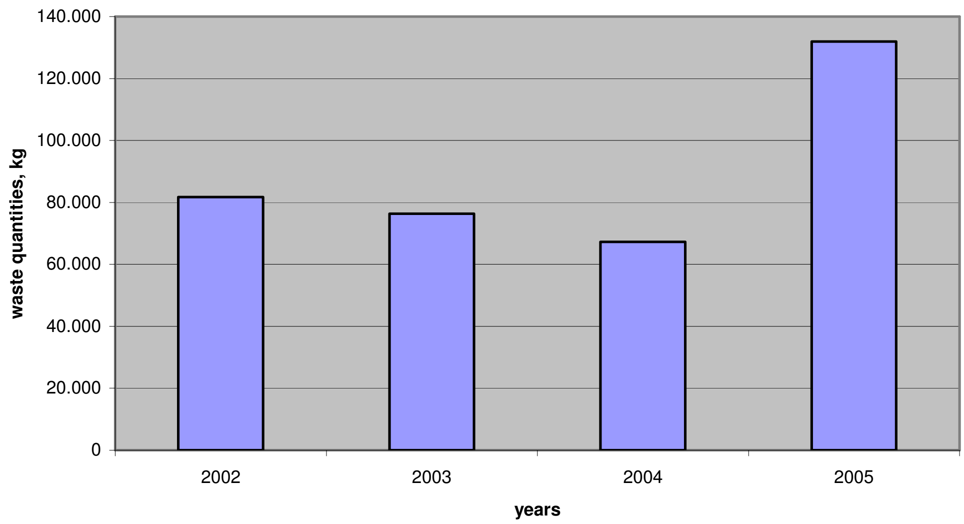


Figure 7.8 Annual quantities of nylon

The usage of nylon on production stage is generally done during packing and packaging, same with plastic material. Besides, nylon wastes are also formed in offices, electric and maintenance departments. Annual quantities of nylon are shown in figure 7.8 and also annual costs of nylon are indicated in figure 7.9.

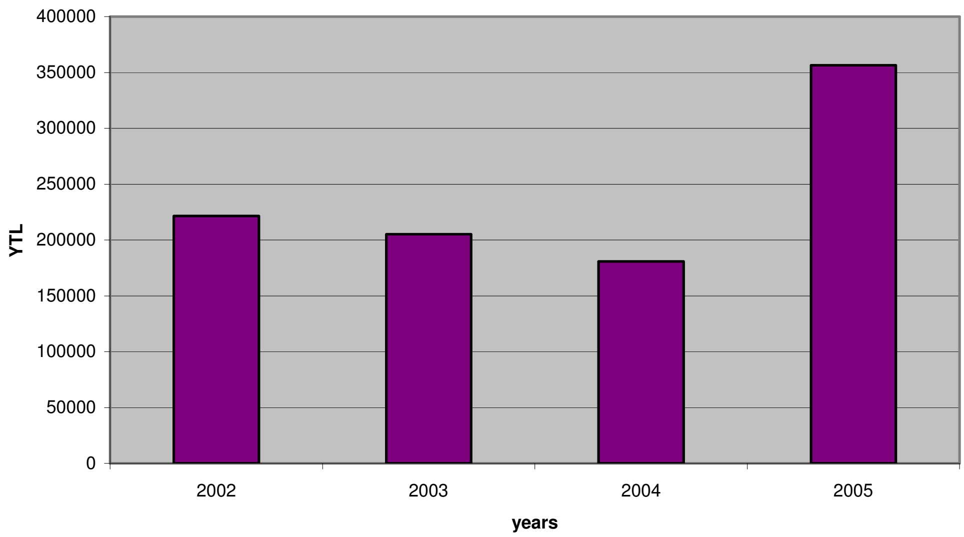


Figure 7.9 Annual costs of nylon

Table 7.6 Amounts of wastes of papers and cardboards

PAPER/ CARDBOARD														
		JAN.	**FEB.**	**MAR.**	**APR.**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT.**	**OCT.**	**NOV.**	**DEC.**	**TOTAL**
2002	HL	94.942	106.449	152.489	156.019	172.329	173.852	185.559	187.020	167.787	141.996	33.530	119.675	1.691.647
2002	KG	19.620	18.700	23.760	23.600	34.540	31.260	70.480	27.540	27.640	18.640	5.860	17.860	319.500
2002	***KG/HL***	***0,21***	***0,18***	***0,16***	***0,15***	***0,2***	***0,18***	***0,38***	***0,15***	***0,16***	***0,13***	***0,17***	***0,15***	
2003	HL	141.873	100.438	166.121	149.303	186.730	198.232	200.004	201.127	170.535	124.846	54.427	113.997	1.807.633
2003	KG	33.420	17.140	43.260	21.720	23.680	30.495	42.400	29.100	25.640	31.560	7.460	31.920	337.795
2003	***KG/HL***	***0,24***	***0,17***	***0,26***	***0,15***	***0,13***	***0,15***	***0,21***	***0,14***	***0,15***	***0,25***	***0,14***	***0,28***	
2004	HL	135.953	125.284	184.340	176.480	178.085	186.032	188.933	200.417	162.148	70.671	90.293	171.474	1.870.110
2004	KG	14.100	12.800	37.260	33.600	36.120	35.000	36.505	28.060	28.960	12.520	14.300	19.280	308.505
2004	***KG/HL***	***0,1***	***0,1***	***0,2***	***0,19***	***0,2***	***0,19***	***0,19***	***0,14***	***0,18***	***0,18***	***0,16***	***0,11***	
2005	HL	111.734	147.469	158.510	178.361	200.060	175.681	192.862	192.407	163.577	61.829	107.520	156.509	1.846.519
2005	KG	12.120	29.980	24.150	30.860	48.470	37.410	30.330	32.413	37.870	13.960	28.752	30.240	356.555
2005	***KG/HL***	***0,11***	***0,2***	***0,15***	***0,17***	***0,24***	***0,21***	***0,16***	***0,17***	***0,23***	***0,23***	***0,27***	***0,19***	
2006	HL	101.033	144.397	141.510										386.940
2006	KG	11.020	29.520	28.200										68.740
2006	***KG/HL***	***0,11***	***0,2***	***0,2***										

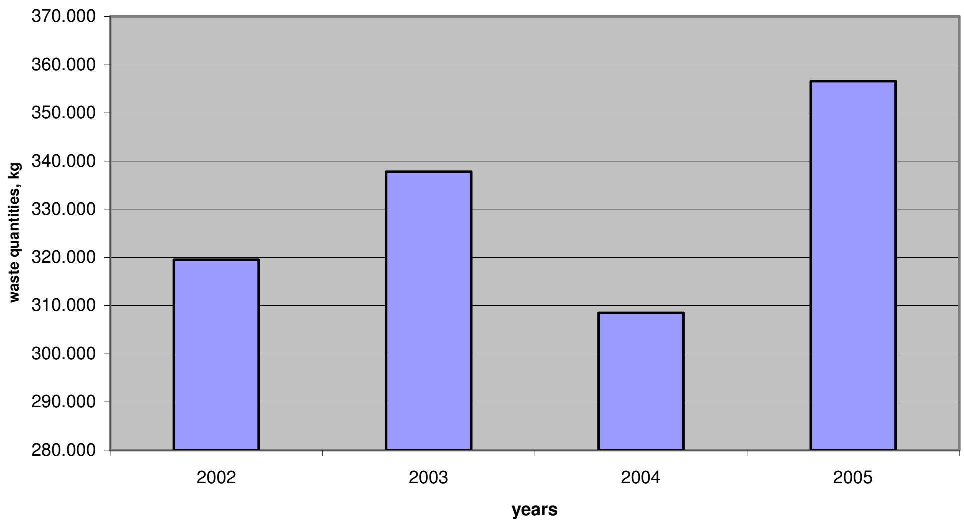


Figure 7.10 Annual quantities of paper/cardboard

The cardboard (paper carton) waste is formed in various departments, especially in the offices. In a factory, recycling boxes are settled in every department in order to collect cardboard wastes. At the same time, these boxes are settled to specific points in the factory, therefore collecting the cardboard wastes is organized. The authorized and contracted institution, ÇEVKO, is collecting these wastes and bringing in to the economy in specific times according to the rules of the contract.

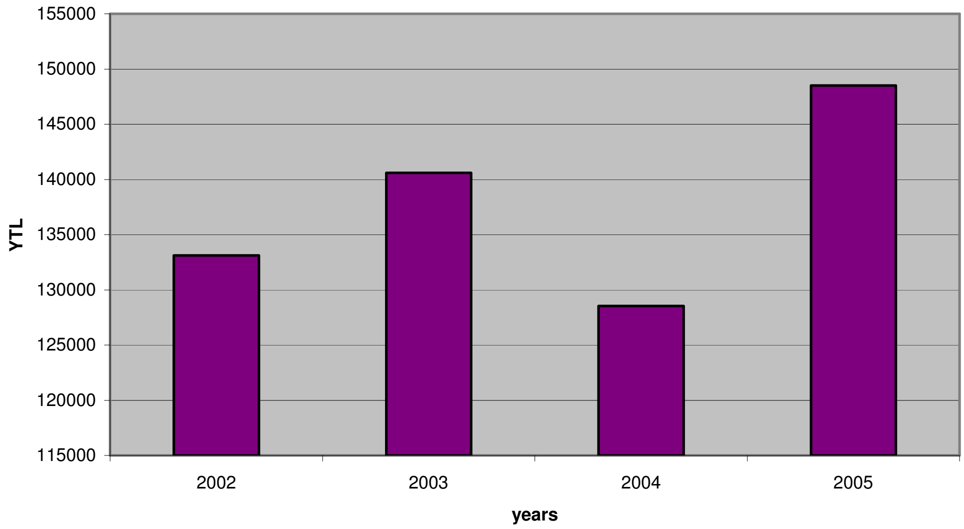


Figure 7.11 Annual costs of paper/cardboard

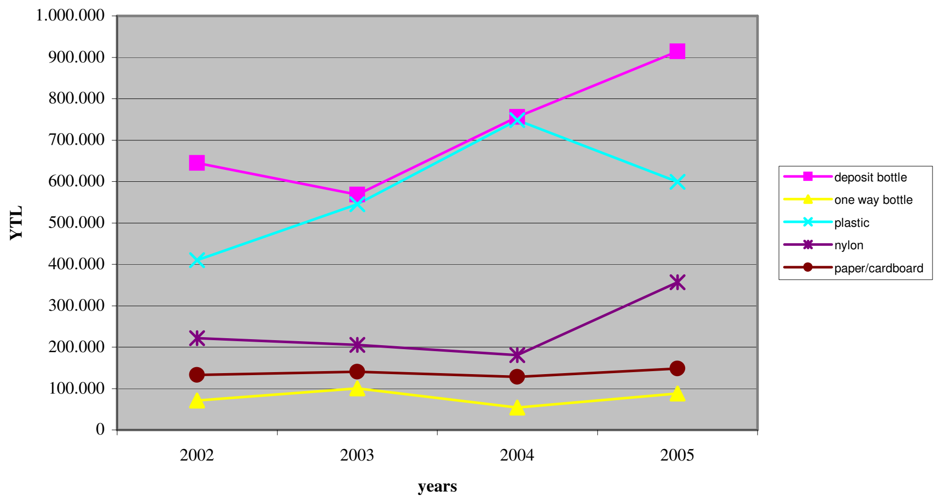


Figure 7.12 Costs of factory wastes

In the Figure 7.12, the costs of wastes which were produced during production were analyzed. This chart was drawn by the information collected from the purchasing department. In the chart costs of glass bottles and plastics are interesting. The amount of plastic wastes are lower than the glass wastes, however the costs of these materials are nearly the same for the factory because of the fact that the unit cost of plastics is 3 times higher than glass.

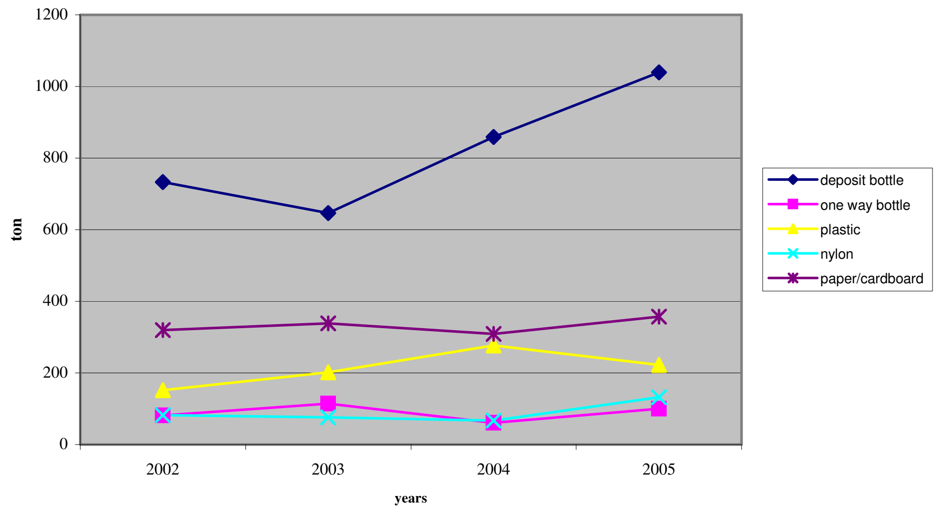


Figure 7.13 Annual amounts of factory wastes in tons

In the Figure 7.13, the amounts of wastes of a beer factory can be seen. The wastes of one way glasses are about 300 tons yearly. Plastic wastes increased in 2004 and 2005 compared to other years. The wastes of nylon and cardboard are nearly the same, about 120 tons yearly. The maximum amount of wastes are wastes of deposit glasses. These wastes are produced especially during filling process. Finally, amounts of waste per unit of production in figure 7.14.

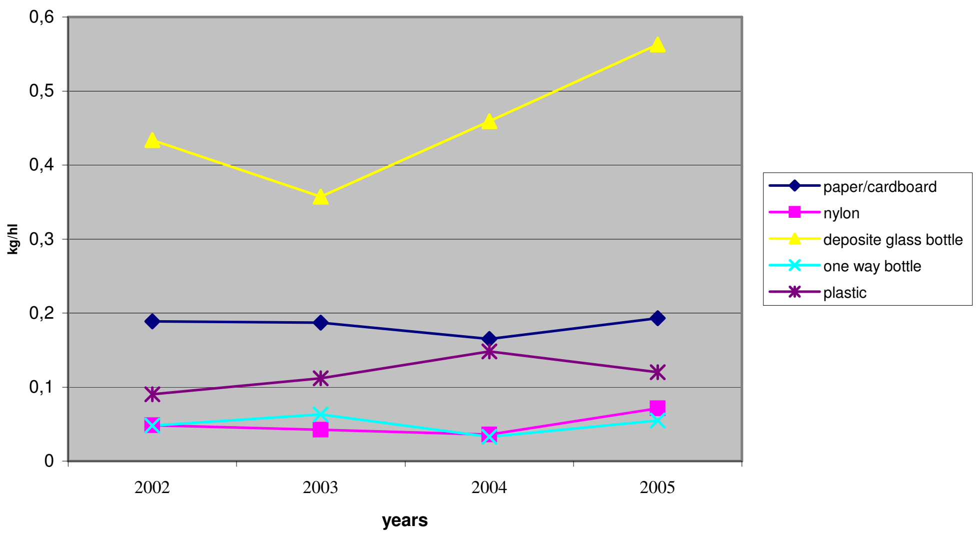


Figure 7.14 Amounts of waste per unit of production, kg/hL

Some recommendations to help waste minimization in different departments;

Reduce for the Workplace: Institution

- Purchase products with the minimum packaging
- Purchase liquid cleaning supplies in bulk
- Purchase food in bulk
- Copy all documents double-sided
- Purchase products in recyclable packaging

Reuse for the Workplace: Institution

- Use re-chargeable batteries
- Purchase reusable printer ribbons and cartridges
- Purchase items that use electricity, not batteries
- Provide employees with reusable mugs

Recycle for the Workplace: Institution

- Office paper
- Mixed paper if marketable in your area
- Corrugated cardboard
- Newspaper
- Aluminum and bi-metal
- Plastic
- Scrap metal
- Glass bottles and jars

Reduce for the Workplace: Retail/Warehouse

- Order items in bulk quantity to reduce packaging
- Ask shippers not to send disposable or hard-to-recycle packing materials
- Ask that your supplies use recycled and recyclable packing materials

Reuse for the Workplace: Retail/Warehouse

- Return corrugated boxes to your supplier for use, or reuse them at your business
- Consider purchasing sturdy, high-quality storage and shipping containers made of plastic, wood, or metal which can be reused indefinitely
- Create your own packing materials by shredding non-recyclable paper items
- Wash and reuse steel and plastic strorage containers that held non-hazardous materials. Some distributors will accept back these containers on a deposit basis

- Repair broken wood pallets for reuse
- Enclose a note in packages to remind recipients to reuse packaging materials
- Save polystyrene pieces and other packing materials and return them to your supplier for reuse or reuse them in your business or donate them to whoever can use them
- Use cardboard or plastic “roll ends” as packing materials. Printers or newspapers would rather donate or charge a small fee for roll ends than pay to dispose of them

Recycle for the Workplace: Retail/Warehouse

- Recycle cardboard that cannot be reused
- Send damaged wood pallets to a lumberyard that can shred them into wooden chips for mulch, or let employees take untreated wood pieces home for kindling
- Purchase recycled packaging materials such as shredded newspapers and cardboard to use for shipping products

Reduce for the Workplace: Office

- Order office supplies in bulk quantities to reduce packaging
- Remove the name of your business from junk mail lists
- Print only the amount of documents you need; don’t “pad the order”
- Use electronic mail to eliminate paper copies
- Review documents on the computer screen before printing to eliminate reprinting
- Circulate only one copy of a memo, letter or publication via a routing slip
- Buy liquid cleaning supplies in concentrate form

Reuse for the Workplace: Office

- Use re-fillable, reusable toner cartridges for laser printers
- Use an erasable memo or chalk board for messages

- Collect and reuse paper printed on one side. A separate paper tray for used paper will make reusing paper easier and help eliminate paper jams
- Convert scrap paper into memo and telephone answering pads

Recycle for the Workplace: Office

- Recycle high-grade white ledger paper
- Recycle other light-colored ledger paper
- Recycle glass and aluminum beverage containers used in the office
- Purchase recycled copier, computer, fax pager
- Purchase recycled notebook paper, envelopes and mailing pouches
- Purchase recycled paper in bulk to reduce costs
- Do not purchase glossy, colored, or hard-to-recycle paper items

Reduce for the Workplace: Manufacturing

- Improve product design to use fewer materials
- Reduce production scrap by modifying production equipment and processes
- Order parts in bulk quantities to reduce packaging
- Have your company name removed from junk mail lists
- Ask your suppliers to use recycled and recyclable packing materials
- Purchase high-quality pallets that are easily repaired

Reuse for the Workplace: Manufacturing

- Maintain equipment properly to reduce wear and extend machinery life. Consider re-manufacturing worn equipment instead of replacing it
- Return corrugated boxes to your supplier for reuse, or reuse them at your company
- Collect cores from plastic, paper and metal rolls for return to the supplier, or reuse them as packaging materials
- Replace paper towels with reusable cloth towels and cleaning rags

- Purchase used instead of new gaylord boxes
- Repair broken wood pallets for reuse

Recycle for the Workplace: Manufacturing

- Include recycled materials in manufactured products whenever possible
- When applicable, collect excess materials for in-house, post-industrial recycling
- Collect metal strapping bands, shavings, and floor sweepings for a metal recycler
- Purchase recycled packaging materials such as shredded newspaper and cardboard when shipping products
- Recycle cardboard that cannot be reused
- Separately collect motor oil, lubricants, and cleaning solvents for recycling
- Send damaged wood pallets to a lumberyard that can shred them into wood chips for mulch, or allow employees take untreated wood pieces home for kindling

CHAPTER EIGHT
CONCLUSIONS & RECOMMENDATIONS

Industrial pollution prevention is a proactive approach to product and process design. It is intended to minimize humanity's effect on the environment by reducing environmental impacts of a product or process throughout the product life cycle. Pollution prevention (P2) techniques can be applied by manufacturers to identfy the potential for waste minimization, energy and raw material usage reduction, and replacement of materials with safer, more environmentally friendly alternatives. The techniques, when applied appropriately, provide the manufacturer with more efficient and environmentally friendly product and processes often resulting in cost savings.

There are various types of wastes, which are produced, in different departments at different times in the factory. This waste differs from themselves in amounts because of various reasons. Forexample, in July, August and September the temperature of weather increases, therefore beer production increases. In the some way, because of the New Year celebrations production increases and therefore wastes increase. The wastes are mostly paper/cardboard, plastics, nylon, one-way bottle and deposit bottles. Also bottle label, printer cartridge, battery, stainless steel material, iron material, copper material, grease cup, aluminium, dye vessel, brass material and organic wastes are the other kinds of wastes. Most of these wastes, especially glass bottles, are generated from filling unit. The other wastes are generally generated from offices, electric maintenance, mechanical maintenance, energy, production and the other departments.

The wastes which were produced in the factory that is analyzed in the concept of the thesis are 7% nylon, 19% paper/cardboard, 56% deposit bottle, 6% one way bottle and 12% plastic.

The most important parameter in solid waste handling is the possibility of separating the waste into different waste categories. In the breweries, most solid waste can be reused or recycled as by-products (Anonym, 2002).

For breweries using returnable bottles, a large portion of the overall brewery waste will be broken glass from the bottling halls. It is possible to recycle the broken glass in the production of new glass at a glassworks, but it is required that the broken glass is relatively free of other materials such as metals and paper. As an alternative, broken glass can be disposed of at landfills. Caution is required in the handling of the broken glass.

Kieselguhr from the filtration of beer also constitutes a very large category. Different methods for regeneration are under development, but presently they are not capable of totally replacing new kieselguhr. The handling of kieselguhr for disposal is therefore limited to increasing the solid content by pressing and disposing at sanitary landfills. In some areas, disposal on farmland can be an alternative. Utilisation in building materials is also possible.

Label pulp from the washing of returnable bottles can be disposed of by composting or recycled into new paper mass. Otherwise the label pulp must be disposed of at sanitary landfills. The paper pulp may contain caustic liquid and heavy metals from label ink.

Breweries using one-way packaging materials such as cans and one-way bottles usually generate large amounts of plastic and cardboard waste. Both the plastic and cardboard should be separated for recycling.

For the rest of the solid waste from breweries, the best applicable handling method is source separation in order to sort out paper, cardboard, metals and wood. In a separated form, most of this waste can be recycled into new material or burned.

Wasted oil from the energy centre and metal shops is a more problematic type of waste. The laboratories will generate waste chemicals from the analyses. Both types of waste must be separated and handled in facilities outside the brewery. Caution should be taken in the storage of these wastes at the brewery. The availability of chemical waste handling facilities is normally the responsibility of the local administration.

The proposed strategies to provide waste minimization and increase recycling ratio are;

1. Training of the workers
2. Regular checking of machinery and replacement of them if necessary
3. Premiums and bonuses for the workers when they succeed the targeted waste ratios
4. Overviewing the production process and trying tofind better process solutions if necessary

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