

Turkish Chemical Industry and Environmentally Friendly Technologies

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Abstract

Turkey has been manufacturing chemicals for a long time, being a producer of many basic and intermediate chemicals, petrochemicals and plastics. Among ca. 6000 companies manufacturing various chemicals, 95 are large scale, 208 are medium scale, and the rest are all small size companies. The southern coast of the Marmara Sea is the home of Turkey's densest population and industrial centers. Most companies in chemical industries, especially private sector companies, are situated in the Marmara Region which, therefore, also generates large amounts of solid and liquid wastes from industrial areas, along with municipal solid waste and sewage as well as air pollution from gas emissions. Large scale industrial companies place a great deal of importance on international standards in production and comply with environmental legislation and regulations. Although Turkey has made great progress over the last fifteen years in creating mechanisms to address its environmental problems, air and water pollution abatement problems still exist due to small scale enterprises generally using old technologies in sub-sectors including highly polluting activities such as textiles/clothing/leather, metal products/machinery/equipment, food/beverages/tobacco, forest products/furniture.

Introduction

Turkey has a number of unique physical, human and economic characteristics that influence environmental conditions. Physically, it is at the crossroads linking Asia, Europe and Africa. The country is surrounded by four seas and has a coastline of 8,333 km. The Aegean and Mediterranean shorelines together exceed 4,500 km while the Black Sea coast stretches to 1,700 km and is shared with Bulgaria, Romania, Georgia, Ukraine and Russia [1]. The Sea of Marmara constitutes the remainder of Turkey's coastal area. Turkey's rugged topography experiences high seismic activity where earthquakes and erosion can pose hazards. Topography and soil conditions allow only a third of Turkey's total land area to be suitable for various types of agriculture, implying pressure on available fertile land. Turkey is generally blessed with an abundance of water resources, though it requires proper management to utilize the water in the most efficient way. Other natural resources whose management should receive attention include certain minerals, forests, fertile soils, and fisheries.

In human terms, Turkey is one of the 20 most populous countries in the world with an estimated 67 million people in 2000 and has the fastest population growth rate of all OECD countries [1]. Population growth rate between 1990-1997 was 15.08% [2]. Economically, Turkey has been growing at double the average for OECD countries with a GNP per capita of \$ 2980 [3]. Industry and tourism are the fastest growing sectors of the economy. In Turkey, as elsewhere, rapid economic growth has accelerated the pace of urbanization and consumption of natural resources as well as increased the amount of waste generated.

Turkish industry has been in a steady growth mode since mid-1980s. Rapid industrial growth was initially concentrated in the coastal regions of western Turkey and thus created urban settlement concerns. 50% of Turkish industry is in the Marmara Region and 18.9% of it is in Aegean Region [4]. Significant increases in quantity and variety of manufactured industrial products have resulted in an increase of industrial waste generation quantities. Environmental impacts of industrialization in Turkey are shown in Fig. 1.

There are number of priority geographical regions in Turkey where several different environmental problem areas converge and create concentrated impacts.

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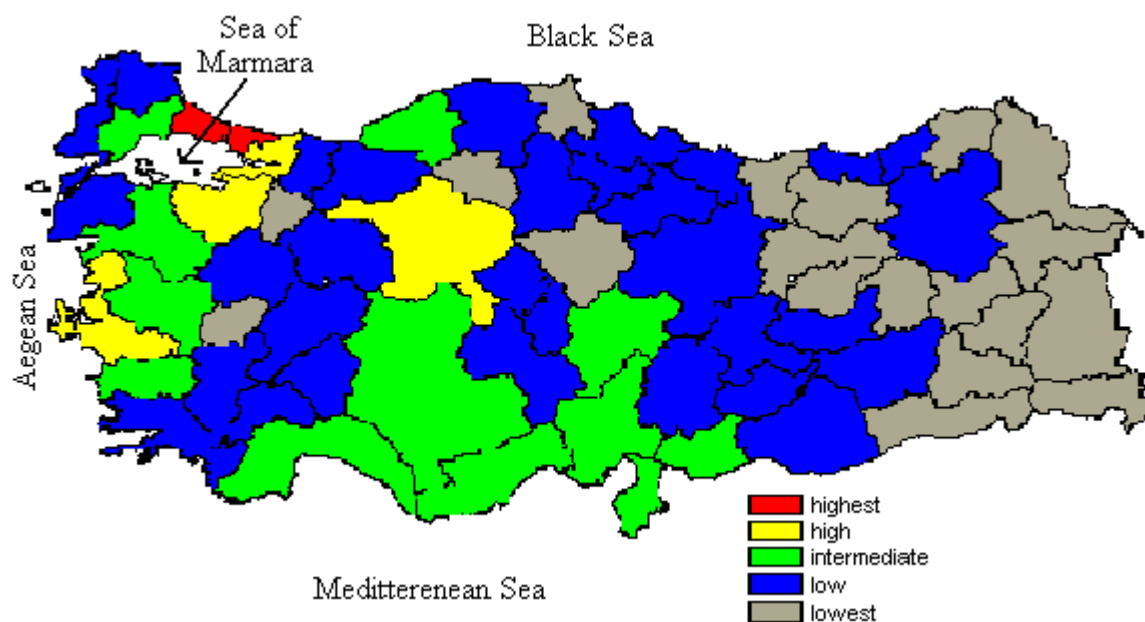


Fig. 1. Environmental Impacts of Industrialization [1].

Çanakkale-Içel coastal zone

The most developed part of the Mediterranean coast suffers from a mix of environmental risks: rapid population growth combined with inadequate infrastructure; rapid tourism development; pressure on natural, cultural and historical sites; agricultural runoff; and pollution from marina and harbour development.

Sea of Marmara and its hinterland

Ecosystems in the Sea of Marmara are threatened by domestic wastewater discharges and urban runoff from metropolitan Istanbul and other cities; industrial air and water contaminants; pollution from the anchoring, loading, unloading and waste disposal activities of ships; and the unique hydrodynamics of the Sea that limit natural purification. These problems persist despite actions such as the Golden Horn Investment Project and the Istanbul Metropolitan Waste Project.

Izmir Bay and environs

The L-shaped Bay along the Aegean coast covers about 920 km² and has been seriously degraded by: (a) very low dissolved oxygen caused by heavy loads of domestic and industrial wastewater; (b) heavy metal pollution from industry; (c) waste from port activities; and (d) hydrodynamic features that cause stagnation and intensify pollution in certain parts of the Bay. The nearby Büyük and Küçük Menderes and

Gediz water basins are also heavily polluted. The partly completed Great Canal Project has found it difficult to address the problems.

Istanbul Province

Turkey's most populous province generates large amounts of solid and liquid wastes from Istanbul and other industrial areas, along with municipal solid waste and sewage, its cultural and historic sites are degraded, it experiences high levels of winter air pollution, and is vulnerable to earthquakes and maritime accidents.

Turkey has made great progress over the last fifteen years in creating mechanisms to address its environmental problems: the 1982 Constitution recognizes the right of citizens to live in a healthy and balanced environment; an Environment Act was passed in 1983; the Ministry of Environment was created in 1991. Thus, Turkey's environmental management system and institutional base were both in place before the 1992 Rio Declaration and Agenda 21 which set forth important changes in environmental protection policies and management systems. Turkey recognizes the necessity to harmonize national environmental policies with approaches adopted by such international documents. Public awareness and demand for a clean environment are growing, and active non-governmental environmental organizations are emerging. Despite these positive developments, environmental issues have not been adequately incorporated into economic and social decisions.

Turkish chemical industry

Turkey has been manufacturing chemicals for very long time, being a producer of many basic and intermediate chemicals, petrochemicals and plastics. Today Turkish chemical industry based on modern technology, has diversified its products and shown steady improvement. There are about 6000 companies manufacturing various chemicals in Turkey. 95 of these companies are large scale, 208 companies are medium scale and the rest are all small size companies [5]. Most of the companies in chemical industries, especially private sector companies, are situated in Istanbul, Izmir, Kocaeli, Adana and Ankara. The trade summary of Turkish chemical industry is shown in Fig. 2.

In conjunction with recent industrial growth in Turkey, the consumption and production of many chemicals are growing rapidly, and the number of chemicals produced is increasing every year. In Turkish chemical industry, there are about 160 companies with foreign investment which have a share of 8.8% of total foreign capital in Turkey. About 35% of foreign capital in chemical industry was invested in industrial chemicals, 37% was invested in plastics industry and 6% was directed to oil and coal products [5].

The coast of the Marmara Sea is the home of Turkey's densest population and industrial centers. Most companies in chemical industries, especially private sector companies, are situated in the Marmara Region (namely Istanbul, Kocaeli and Bursa), Izmir, Adana and Ankara. In conjunction with recent industrial growth in Turkey, the consumption and production of many chemicals are growing rapidly, and the

number of chemicals produced is increasing every year. Therefore, Marmara Region also generates large amounts of solid and liquid wastes from industrial areas, along with municipal solid waste and sewage as well as air pollution from gas emissions.

Turkish companies place considerable importance on complying with international standards in production. Turkey has reached the world standards as far as raw materials, semi-finished and finished products and trained staff are concerned. Large scale industrial companies place a great deal of importance on international standards in production, and comply with environmental legislation and regulations. Full implementation of the Customs Union with Europe and candidate to membership of the European Community increase pressure for higher standards of environmental quality. Most large scale companies in chemical industry have ISO9000 Quality System Certificates, and the number having ISO14001 Certificates is increasing. Besides, 98% of the members of Turkish Chemicals and Manufacturers Association (TKSD) have committed to the Responsible Care Program [6] which is the worldwide chemical industry's commitment to continual improvement in all aspects of Health, Safety and Environment performance and to openness in communication about its activities and achievements. The program is regularly audited and monitored by TKSD.

Petrochemicals Industry

The petrochemical industry in Turkey is based on naphtha feedstock, and most of the feedstock is provided from TUPRAS refineries while the remaining amount is imported. The dominant organization in the

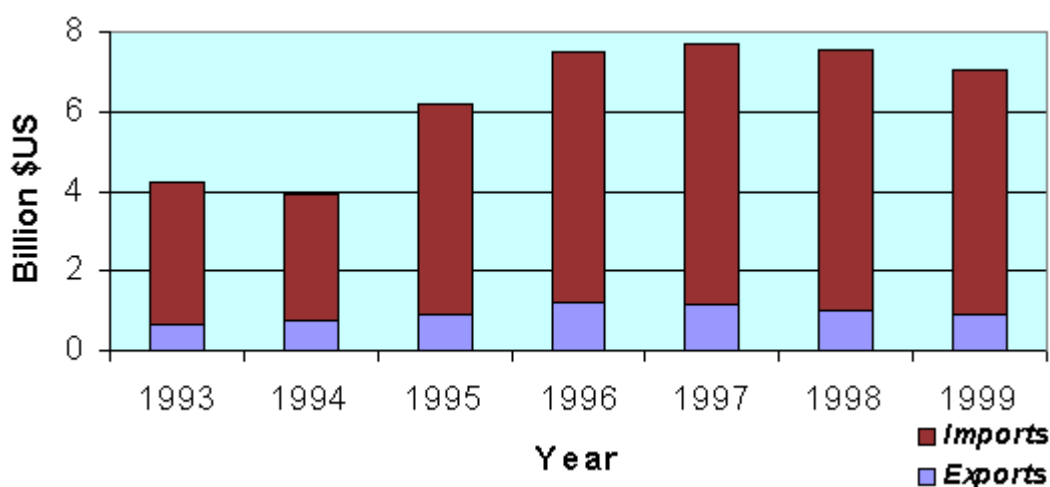


Fig. 2. Turkish Chemicals Trade Summary [6].

Turkish petrochemical sector is PETKIM Petrokimya Holding which is a public company. There are two petrochemical complexes of PETKIM, one is in Kocaeli (Yarimca Complex) and the other one is in Izmir (Aliaga Complex). In these two complexes a wide range of petrochemicals, all common plastics (HDPE, LDPE, PS, PVC, PP), aromatics, ethylene glycol, phthalic anhydride, terephthalic acid, carbon black, synthetic rubber, acrylonitrile and caustic soda are produced.

Besides PETKIM there are no other big companies acting in the basic petrochemicals industry other than SASA with an annual production capacity of 250,000 tons of dimethyl terephthalate and BASER KiMYA with an annual production capacity of 50,000 tons of polystyrene. However, there are investments mainly aimed for end products as downstream of basic petrochemical products [7].

In Turkey, the growth rate of demand for petrochemical products especially in thermoplastics is three times more than world averages. For the last ten years, this rate has been 11.8% per year on the average. Despite this high figure, thermoplastics consumption per capita is still very much lower than that of developed countries. While thermoplastics consumption per capita in the developed countries is 80-100 kg, in Turkey this figure is about 25 kg which is a little higher than the world average of 18 kg [8].

In the consciousness of protecting environmental values, using all resources from raw materials to energy in the most productive and effective way, PETKIM, which voluntarily signed the «Responsible Care» initiative, targets continual improvement in all aspects of health, safety and environmental performance. PETKIM is modernizing waste treatment units by using new technologies continuously, increasing capacity and working sensitivity by additional investments. As a result of one of these investments, PETKIM has changed the Hg-cell process operated since 1985 by ion-exchange membrane cell system in June 2000. There are still four chlorine-alkali plants with mercury cells of other companies in Turkey.

Petroleum Products Industry

TUPRAS-Turkish Petroleum Refineries Corporation, a public sector company, is the main producer of petroleum products with a capacity of 27.6 million tons per year. Private sector operates only one refinery (ATAS) with a capacity of 4.4 million tons per year. Four refineries of TUPRAS, located in Kocaeli, Izmir,

Batman and Kirikkale, produce LPG, naphtha, premium and regular gasoline, unleaded premium gasoline, jet fuel, gas oil, kerosene, lube oil, sulphur, fuel oils, asphalt and other petroleum products.

All refineries have water treatment units, and the quality of wastewater is within the limits of environmental standards. SO₂, NO_x, CO_x, hydrocarbon and particulate emissions due to low quality fuel oil and inefficient combustion of it and solid wastes are the major environmental problems of this sector. Another environmental problem is the quality of products. Sulphur, aromatics and benzene contents of the unleaded gasoline are higher than European standards, and also, leaded gasoline production is much higher than unleaded gasoline production. However, TUPRAS has some investments and projects for increasing products quality and minimizing the production wastes in order to achieve European standards by 2005 [9].

Plastics and Rubber Industry

The domestic production of basic plastic raw materials naturally resulted in a strong plastics processing industry. Plastics processing industry together with rubber processing industry has a share of 6% in the manufacturing industry of Turkey. Turkey manufactures all kinds of plastic products, ranging from traditional to the latest developed products, such as plastic construction and irrigation products, auto parts, table and kitchenware, all plastic parts of electronic, electrical and household items and all kinds of plastic packaging products. At present, there are about 4000 plastics processing companies in the country that are mainly small and medium scale [5].

In Turkish rubber industry there are four major automotive tires manufacturing companies (Brisa, Pirelli, Goodyear and Petlas) and about five hundred small scale and medium scale companies producing and processing different kinds of rubber products. The large-scale companies strictly obey the environmental regulations and their waste management systems are as good as in European Union countries. However, there are water and air pollution problems in the small and medium scale enterprises, some of which are still using chemicals producing nitrous-amines.

Textiles Industry

Since textiles sector is well-developed in Turkey, polymer production related to textiles has also devel-

oped simultaneously. Large plants have been built for the production of polyamide, polyester and acrylic fibers, and production has been directed to both foreign markets and domestic market.

Turkey has around 400 textiles dyeing and finishing companies and 70% of them are located in the Marmara Region [10]. 58.4% of these companies are medium sized. Since Turkey is the 6th highest cotton producer of the world, most of the dyeing and finishing companies in the Turkish textiles industry are based on cotton dyeing, bleaching and finishing.

In recent years, production costs in the textiles industry have decreased due to increases in production of textile dyes in Turkey. Production of textile dyes in Turkey increased from 1910 tons to 5200 tons in the years between 1992-2000 [10].

Costs of energy, chemicals and dyes, water supply and water treatment are the important factors that influence the price of product in the textiles sector. Energy consumption in the Turkish textiles industry is much higher than in Europe and USA, and most of the companies use fuel oil. Therefore, using clean and cheap fuels will be a solution for the problems of the textiles industry. Water recycling is another important process in the future of textiles industry in Turkey, since water is an essential utility for this sector. At present, all companies obtain their water supply independently from underground resources that are decreasing sharply. In textiles industry almost all companies have wastewater treatment units or are located in the organized industrial regions which have common wastewater treatment units. However, the treatment yields of some companies are not good enough due to high utilization costs of these units and insufficient control by governmental agencies.

Fertilizer Industry

Fertilizer industry is one of the key industries of Turkey, which has vast agricultural potential. Today there are six companies producing fertilizers exclusively. Two of these are in the public sector and operate 12 plants. The private sector operates 6 plants. In addition, three iron and steel companies (two which are public sector) produce fertilizers as a by-product and operate 3 plants. Among these companies only IGSAS that is a public company has ISO 9002 Quality System Certificate [11].

Although some of the companies have modernization plans for the introduction of environmentally friendly technologies, accelerated privatization of

some public companies having obsolete technologies, combined with environmental requirements, is necessary for reducing pollution in the fertilizer industry. Environmental pollution due to wrong use of fertilizers has not been encountered in Turkey yet, as the amounts of fertilizers used per unit area low. Increases in the consumption of fertilizers in the future may cause such environmental problems unless the farmers are educated on the correct use of fertilizers.

Pharmaceuticals Industry

The pharmaceuticals industry has become one of the leading sectors of the chemical industry and accounts for approximately 20% of the chemicals production. Turkish pharmaceutical market has a great volume due to the population of about 65 million. There are 196 companies in this sector, and 84 of them are production companies among which only two of them are public companies [12].

Common pharmaceuticals are generally produced in Turkey, and those produced by newest technologies are imported. 90% of the raw materials of pharmaceuticals are imported. The companies in the Turkish pharmaceuticals industry can be grouped into four types [12]:

- i) Foreign production companies that have built their own production plants many years ago and have produced their products in these plants: Bayer, Glaxo-Wellcome, Hoechst, Novartis Pfizer and Roche are some examples.
- ii) Foreign production companies that have license agreements with their Turkish counterparts and produce their products in the plants of these counterparts. Chugai, Pharmacia-Upjohn, Sanofi, Syntex, Warner-Lambert are within this group.
- iii) International companies that have only marketing activities in Turkey and sell the products produced on behalf of their companies in different national and international plants. Bristol Myers-Squibb, Merck Sharp and Dohme, Smithlinke Beecham, Wyeth are some examples of these companies.
- iv) National production companies that have their own licences or have license agreements with international companies. Abdi Ibrahim, Bilim, Deva, Eczacibasi, Fako, Ibrahim Ethem, Mustafa Nevzat are among major Turkish pharmaceuticals companies.

Pharmaceuticals industry in Turkey complies en-

tirely with environmental legislation and regulations, and the number of companies those having ISO 14001 certificates are increasing every year.

There are only 10 companies producing raw materials and fine chemicals for pharmaceuticals industry in Turkey. Almost all are located in Istanbul and Kocaeli, and only one of them is a public company [12]. All companies have biological and chemical wastewater treatment units and gas absorption and combustion systems for polluted gas emissions.

Soap and Detergent Industry

Turkish soap and detergent industry has shown a very good performance in terms of quality and capacity. There are many companies in the soap and detergent industry; about 15 of them being the major producers; among these companies are multinational groups which enjoy worldwide reputation [5]. Large scale industrial companies place a great deal of importance on international standards in production and comply with environmental legislation and regulations. However, air and water pollution abatement problems still exist due to small-scale enterprises generally using old technologies.

Paints and Coatings Industry

Parallel to the developments in construction, automotive and marine industries of Turkey, paints and coatings industry has also developed and has become one of the most dynamic sectors of the Turkish chemical industry. There are about 400 manufacturers, nearly 10 of which are large scale companies [5]. 60% of the companies use modern technologies and comply with the environmental regulations.

Mining Industry

Turkey has the largest soda factory in the Middle East. In addition to light and dense soda ash, refined sodium bicarbonate and sodium silicate are produced at the Mersin plant that strictly obeys environmental regulations [13].

Turkey also enjoys a comparative advantage in boron chemicals (borax decahydrate, borax pentahydrate, boric acid and sodium perborate) due to the size of her reserves (65% of the world reserves), the quality of minerals and proximity to the consumer markets. Eti Bor is the only company with three plants in this sector, and investments have been made to pre-

vent environmental pollution by its plants. The company also has some improvement projects and new investments in order to reduce solid waste in the production of boron chemicals [13].

Being among the top five countries supplying chromium ore to the world markets, Turkey produces and exports some of the major chromium chemicals, such as sodium bichromate and basic chromium sulphate.

Survey of serious industrial sources of wastes in Turkey

Air Pollution Sources

Turkey's three principal energy sources – petroleum, lignite and fuel wood – are the most responsible for ambient and indoor air pollution. SO₂ and NO_x emissions mainly stem from combustion of very low quality lignite by industries, energy transformation and households using outdated and polluting technologies. Also, the relatively low efficiency of energy usage by industries, transport and households results in higher consumption of energy resources and higher levels of pollution. Moreover, power plants routinely exceed the SO₂ emission standard. 60% of the power plants in Turkey are fossil-fuel power plants and 53 % of total power production of Turkey is obtained from power plants using lignite [14].

Air pollution from motor vehicles is a persistent and growing problem. There are large amounts of old technology vehicles without catalytic converters. Fuel pricing is also not consistently applied to limit the use of polluting fuels. Unleaded fuel is sold at about the same price as premium leaded fuel, so consumers have no incentive to switch. Unleaded gasoline production was only 19% of national petroleum production in 1999 [9]. On the other hand, sulphur, aromatics and benzene contents of the unleaded gasoline in Turkey are higher than those set forth by European standards.

On the positive side, city-specific data indicate that ambient air pollution from particulates and SO₂ has significantly declined during the first half of the last decade, due to two major decisions concerning the fuel mix. First, low quality, high-sulphur domestic coal was prohibited for household heating and was replaced by higher quality imported coal. Second, major investments were made in supply pipelines, household distribution networks to substitute natural gas for coal in several cities.

Design of catalytic gas filters for toxic gases, NO_x and CO₂ emissions, use of clean and renewable energy sources and efficient combustion of fuels should be considered as major solutions of air pollution problems of chemical industry in Turkey.

Water Pollution Sources

Small industries pose a special wastewater pollution problem since environmental policies (e.g. incentives to modernize technology) and services such as waste treatment and environmental education has been so far limited. Discharges from small enterprises are poorly managed. Only 34.6% of all industrial enterprises are located in small industrial sites, and only 1.4% are in organized industrial estates [1]. Turkey has 190,000 small enterprises (up to 24 employees) that employ 43% of the industrial workforce. These enterprises are concentrated in sub-sectors including highly polluting activities such as textiles/clothing/leather, metal products/machinery/equipment, food/beverages/tobacco, and forest products/ furniture.

Rapid urban population growth and industrialization have strained liquid waste management systems, and utilities have been unable to keep pace with growing demand. Industrial pollution has been inadequately controlled, only low levels of industrial wastewater has been treated. Industrial growth was most rapid in the chemical, petroleum, coal, and rubber industries, followed by paper and printing, and food/beverages/tobacco. Although industries that produce hazardous wastewater are required to pre-treat their effluents before discharge, treatment facilities are limited. Even if they exist, many do not operate properly. Operation of hazardous waste treatment facilities and disposal is the responsibility of metropolitan municipalities. However, since municipalities are constrained by low sewerage charges, lack of investment capital and inadequate staff, very low levels of domestic wastewater are treated. The bulk of untreated or partially treated sewage is discharged into surface water. Seepage from sewage systems and open solid waste dumps that contaminate groundwater are the main causes of degraded water quality. Another source of water pollution is the pesticides polluting the soil and water, banned elsewhere but still used in Turkey [1].

Expanding the quantity and quality of wastewater treatment facilities, and encouraging more private sector involvement in water and wastewater utilities, in provision and management; and enforcing industrial wastewater treatment standards and measures

especially in state enterprises, establishing organized industrial regions that group small enterprises working in the same sector and provide suitable infrastructure and services are the major subjects that should be considered to get rid of water pollution problems in Turkey.

Solid Wastes

Although a solid waste control regulation emphasizing recycling and safe disposal was introduced in 1991, the level of programs and policies to reduce, reuse and/or recycle solid wastes is low. The record of state enterprises is poor. They send 54% of industrial solid waste for disposal, rather than recycling, reusing or selling it, compared to the 21% of private firms. As with wastewater treatment programs, they can avoid regulations because one government agency cannot enforce its policies and rules on another. Outside of cities, mining and rural power plants are important sources of industrial waste.

Local capacity with respect to financial resources, equipment and staff is low. Rapid urban population growth has strained the systems for solid waste management, and municipalities have been unable to keep up with growing demand in the rapidly expanding peripheries. Also, for solid waste management, the two most common approaches adopted in other countries (contracting collection services and concession contracts for developing and operating waste disposal facilities) are difficult to implement.

There is only one hazardous waste landfill operated in Izmir and one hazardous waste incineration plant is nearing completion in Kocaeli. Some major cities are only now building or operating their first sanitary landfills (e.g. Ankara, Bursa, Gaziantep, Istanbul, Izmir, Mersin) [15]. Today, mostly small and medium scale enterprises send their toxic and hazardous solid wastes to the domestic open dump sites of municipalities. Open dumps experience problems with leachate that contaminate surface and groundwater, and create odors, fires and methane gas explosions. Dumping into seas, lakes and rivers pollutes these bodies, while open burning contributes to air pollution.

Conclusions

Throughout the 1990's, "Green Chemistry" has been recognized as a new scientific approach to environmental protection in developed countries. In

the meantime, the Seventh Five Year Development Plan of Turkey (for years 1996-2000) states that Turkey should develop a national environmental policy emphasizing pollution prevention rather than clean-up. Research and development in environmentally-sound technologies and in effective use of energy and environment-friendly renewable energy technologies, and nation-wide applications are the suggestions within the framework of the Turkish Science and Technology Policy for the years 1993-2003. Based on these policies, Turkey has made great progress in the solution of her environmental problems. Government has supported many projects on technology upgrading through the Scientific and Technical Research Council of Turkey (TUBITAK) and the Technology Development Foundation (TTGV).

Signing of the Customs Union with the European Union in 1995 and candidacy to the membership of the European Union in 1998 have also increased pressure for environmentally friendly production processes in Turkish industry. Almost all large scale companies have investments to improve their technologies for obtaining ISO 9000 and 14001 certificates.

Among new investments in the Turkish industry is the phasing-out of ozone depleting substances (ODS). In 1992, the Government of Turkey, with the assistance of the World Bank, developed a strategy for the phase-out of ozone depleting substances (ODS) as part of the Country Programme. Although Turkey is an Article 5 country, the government has decided to phase-out ODS usage in manufacturing by the year 2000 [16]. At present, major refrigerator and foam companies have converted their production lines to new technologies using ODS-free agents. These achievements and an award given by United Nations in 1997 show that Turkey is as good as the developed countries in this respect.

The ODS phase-out management scheme now needs to be extended to small enterprises including the sector of refrigeration servicing. This is a more tedious and difficult process than technological change realized at the large scale industries. The reasons behind are lack of economical incentives, proper training, the complex structure of small enterprises and the servicing sector in Turkey and lack of sub-structure for recovering and recycling CFC's. The Technology Development Foundation (TTGV), founded by the joint efforts of private and public sectors, has been given the responsibility for identifying and preparing investment projects for ODS phase-out in all the ODS consuming sector, for informing particularly

small and medium sized enterprises about the requirement to phase-out ODS use and about the technology options and assistance available to them to switch to alternatives; TTGV is also to prepare demonstration projects to further assist in providing information on phase-out possibilities in each sector as well as supervising and monitoring the sub-projects [16].

Some other examples of environmental friendly technologies introduced recently may be summarized as follows:

- Petkim has completed the project for the conversion of the chlorine-alkali plant from mercury cell technology to membrane cell technology in the year 2000.
- Tupras refineries have investments on the projects for producing unleaded gasoline in EU norms by the year 2005.
- Chemicals producing nitrous-amines are not being used anymore by major tires manufacturing companies.
- Linear alkyl benzene (LAB) has been used instead of dodecyl benzene sulphonate in soap and detergent industry since many years.

Since Turkey is presently undergoing a transition from pollution abatement to pollution prevention, the investments for clean-up technologies are continuing during this transitional phase. Management of industrial waste is top priority in environmental protection efforts of Turkish industry. Currently, there is an urgent need for regulated waste recovery and disposal facilities at adequate numbers and capacities.

In the consciousness of protecting environmental values, using all the sources from raw materials to energy in the most productive and effective way, the companies that have signed the «Responsible Care» initiative are modernizing waste treatment units by using new technologies continuously, increasing the capacity and the working sensitivity by additional investments. Involving the small and medium scale enterprises (SME's) in «Responsible Care» commitment is among the planned activities of TKSD for the 2000's.

Environmental problems linked with SME's will have been solved by establishment of organized industrial regions. A general nationwide evaluation shows that [17] SME's occupy an important place in the economic and social fabric of Turkey, in terms of three important indicators including the number of enterprises, the number of employees and value added. KOSGEB (Small and Medium Industry Development

Organization), a public agency associated with the Ministry of Industry and Trade, has been created in order to help these enterprises to adapt to scientific and technological innovations swiftly with view to ensuring that they operate effectively so that both their competitiveness and revenues increase, resulting in greater contribution to our economy at the macro level.

An integrated waste treatment project (first of its kind) for the highly polluted Kocaeli area is nearly completed. It includes a sanitary landfill for municipal and industrial solid waste, an incinerator for medical and hazardous wastes, a wastewater treatment plant, sewage interceptor and river rehabilitation. Also, Industrial Chambers of Kocaeli and Istanbul have activated the Waste Stock in 1999.

The private sector is a key environmental actor, as its enterprises generally perform better than state enterprises in Turkey, treating almost twice as much of their wastewater and spending less than half as much for final disposal. State enterprises generate more than half the industrial solid waste and industrial discharges of BOD and COD. This implies that accelerated privatization of state enterprises, combined with appropriate environmental safeguards and requirements, could reduce industrial pollution. As private enterprises also provide environmental goods and services, they maintain expertise and supply equipment for wastewater treatment, water purification, solid waste management and air pollution control

The adaptation of innovative chemical technologies that incorporate the principles of Green Chemistry into chemical design, manufacture and use by chemical industries, especially SME's, will be a key issue for the achievement of Turkey's economic and environmental goals. Priority projects are needed for integrating the environment into development planning of Turkey.

It should be stressed that advanced material technologies, new biotechnology and genetic engineering are progressing towards becoming global technologies, and these technologies are likely to play a key role in the 21st century that is comparable to the role of information technology today. Catalysts which are considered as advanced materials play a major role in the developments of alternative environmentally benign manufacturing technologies. Catalysis for sustainable chemistry is an important scientific and technological area for the development of environmentally friendly chemical processes.

Because of lack of regulatory enforcement in the environmental protection field, extensive use of

catalytic technologies is not widespread in Turkish industry. Most of the industrial process equipments are utilizing end-of-pipe solutions for environmental protection issues at the plant level. Converting to catalytic technologies will require informing the upper management of the companies and training of the plant managers on more effective technologies. Also, country-level institutional mechanisms and some specific incentives on the use of the new technologies, along with demonstrated cost/benefit analyses, would be helpful to encourage the companies to consider utilization of catalytic technologies. Periodic technical expositions and symposia on catalytic technologies would also be useful for the industry sectors.

The following are the industry sectors that can benefit from clean-technology programs involving catalytic technologies in the initial phase:

- Textiles (involving chemical treatment)
- Leather tanning and dyeing
- Foundries,
- Chemicals
- Automobile auxiliaries
- Power cogeneration

In conclusion, although still strong action is needed, sensible changes are underway in the design approach of Turkey's sustainable environmentally benign development.

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References

1. State Planning Organization, "TURKEY: National Environmental Action Plan", May 1998. Ankara. [<http://ekutup.dpt.gov.tr/cevre/eylempla/neap.html>]
2. State Institute of Statistics, 1997, Ankara. [<http://www.die.gov.tr/TURKISH/SONIST/NUFUS/Nufus97.htm>]
3. State Institute of Statistics, 2001, Ankara [<http://www.die.gov.tr/TURKISH/SONIST/GSMH/31300t.html>]
4. State Planning Organization, Eight Five Year Development Plan of Turkey, OIK 545, 2000, Ankara

5. IGEME-Export Promotion Center of Turkey, "Chemical Industry of Turkey", February 1998, Ankara
6. Zambak, C., "Responsible Care-Implementation in Turkey (Presentation for Peer Review)", CEFIC - RCLG 2000 Meeting, 20 - 22 September, 2000, Lisbon, Portugal
7. State Planning Organization, Eighth Five Year Development Plan of Turkey, OIK 579, 2001, Ankara
8. Petkim Annual Report, 2000, Aliaga-Izmir
9. State Planning Organization, Eighth Five Year Development Plan of Turkey, OIK 551, 2000, Ankara
10. State Planning Organization, Eighth Five Year Development Plan of Turkey, OIK 565, 2001, Ankara
11. State Planning Organization, Eighth Five Year Development Plan of Turkey, OIK 531, 2000, Ankara
12. State Planning Organization, Eighth Five Year Development Plan of Turkey, OIK 556, 2000, Ankara
13. State Planning Organization, Eighth Five Year Development Plan of Turkey, OIK 580, 2001, Ankara
14. Milliyet-Thema Larousse, Vol. 3, 1994, Istanbul
15. State Planning Organization, Eighth Five Year Development Plan of Turkey, OIK 524, 2000, Ankara
16. TTGV, "The status of ozone depleting substances phaseout in Turkey", 2000, Ankara [<http://www.ttg.gov.tr/eng/ozonek.html>]
17. [<http://www.kosgeb.org.tr/kosg.html>]

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