International POPs Elimination Project

Fostering Active and Efficient Civil Society Participation in Preparation for Implementation of the Stockholm Convention

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PETKIM Petrochemical co. (PVC Plant)

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About the International POPs Elimination Project

On May 1, 2004, the International POPs Elimination Network (IPEN http://www.ipen.org) began a global NGO project called the International POPs Elimination Project (IPEP) in partnership with the United Nations Industrial Development Organization (UNIDO) and the United Nations Environment Program (UNEP). The Global Environment Facility (GEF) provided core funding for the project.

IPEP has three principal objectives:

- Encourage and enable NGOs in 40 developing and transitional countries to engage in activities that provide concrete and immediate contributions to country efforts in preparing for the implementation of the Stockholm Convention;
- Enhance the skills and knowledge of NGOs to help build their capacity as effective stakeholders in the Convention implementation process;
- Help establish regional and national NGO coordination and capacity in all regions of the world in support of longer term efforts to achieve chemical safety.

IPEP will support preparation of reports on country situation, hotspots, policy briefs, and regional activities. Three principal types of activities will be supported by IPEP: participation in the National Implementation Plan, training and awareness workshops, and public information and awareness campaigns.

For more information, please see **http://www.ipen.org**

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The views expressed in this report are those of the authors and not necessarily the views of the institutions providing management and/or financial support.

This report is available in the following languages: English language, Turkish language

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1. Physical description of site

The coastal country, Aliaga, is located at 38^0 26 $^/$ latitude and 27^0 08$^/$ longitude.
Aliaga, located in Ege region, is a conjunction county to the city of Izmir, and has a surface area of 3.932 km^2 . The landscape is mostly plain with some mountain formations: Mount Dumanli to the southeast of the county and Mount Yunt in the northeast. Generally mountains extend parallel to the coastline from west to east.

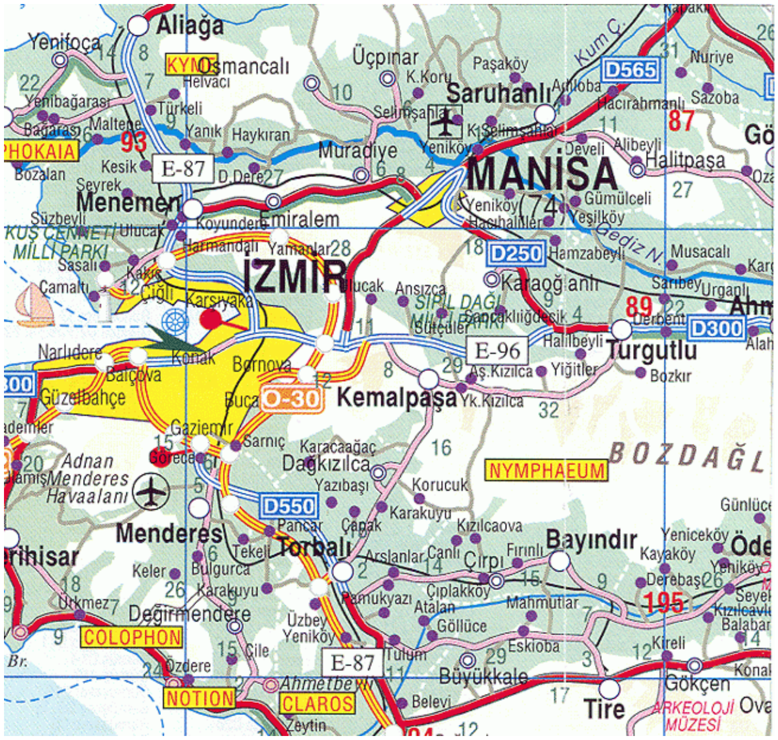

FIGURE 1: Map of IZMIR and ALIAGA

FIGURE 2: Location of Petkim Aliaga Complex

Aliaga Petrochemical Complex, which is 55 km north of Izmir (FIGURE 1), has fourteen main process factories and eight auxiliary units. Aliaga was a fishing center until metal, petrochemical, paper and chemical fertiliser industries settled there in the 1980s. Even though the area includes the ancient city of Kyme and sandy beaches, it no longer has any attraction for vacationers. The Foca region which is 25 km south of Aliaga is an important breeding area for the threatened Mediterranean monk seals.

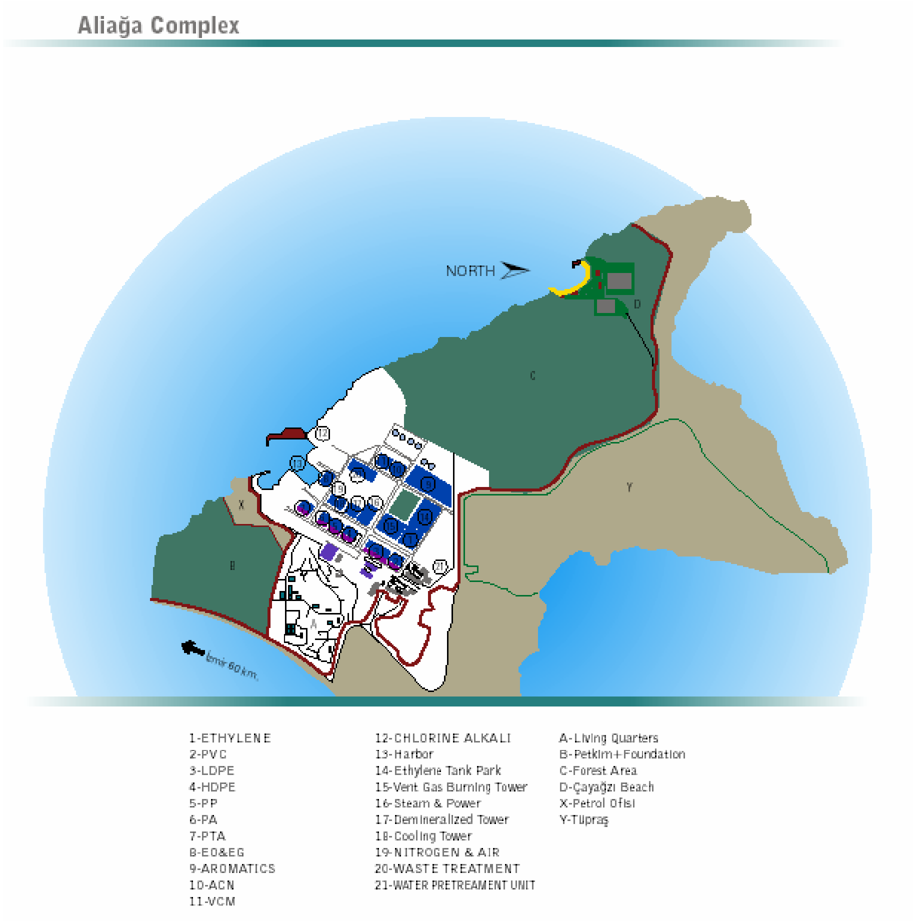

FIGURE 3: Plants' locations at Aliaga Complex

PLANTS AT ALIAGA

- **Ethylene Plant**
- **Low Density Polyethylene (LDPE) Plant**
- **High Density Polyethylene (HDPE) Plant**
- **Polypropylene (PP) Plant**
- **Acrylonitrile (ACN) Plant**
- **Ethylene Oxide / Ethylene Glycol (EG) Plant**
- **Aromatics Plant**
- **Pure Terephthalic Acid (PTA) Plant**
- **Phthalic Anhydride (PA) Plant**
- **Chlorine Alkali (CA) Plant**
- **Vinyl Chloride Monomer (VCM) Plant**
- **Polyvinyl Chloride (PVC) Plant**
- **Bag Production Unit**
- **Masterbatch Unit**

UTILITY UNITS AT ALIAGA

- **Guzelhisar Water Dam**
- **Water Pretreatment Unit**
- **Demineralized Water**
- **Steam Generation Unit**
- **Power Generation Unit**
- **Nitrogen & Air Supply Unit**
- **Waste Water Treatment Unit**
- **Harbor**

Both Aliaga (FIGURE 3) and Yarimca complexes discharge their wastewater after treatment directly into the Mediterranean and Marmara seas. The waste is dumped on the shore of the Mediterranean Sea inside the Aliaga complex site (The Dark Side of Petkim 2000 – Greenpeace document).

The air pollution caused by the industries in the Aliaga area is visible. The air emission control systems of the factories are totally inadequate. Some 9.7 ton/hour of SO_2 and 0.67 ton/hour NO_x gases are emitted from the factories in the area (Muezzinoglu *et al.*, 1994). Aliaga Petkim itself is responsible for almost half of these emissions.

Petkim Aliaga complex is a large PVC production site, manufacturing ethylene dichloride (EDC) and vinyl chloride monomer (VCM) as well as PVC. Chlorine and sodium hydroxide are also produced from the electrolytic separation of brine solution. (The Dark Side of Petkim 2000 – Greenpeace document)

The Petkim plant, along with the shipyards and the petroleum refinery located nearby, pollute the sea with their discharges. Local fishermen report that the wastewater discharged by Petkim emits noticeable foul odours and sometimes kills many fish. Petkim discharges more than 26,000 cubic meters of wastewater daily. Amazingly, although this industry produces and releases so much waste, it is self-regulating and not subject to any independent inspections (Muezzinoglu *et al.* 1994). Other wastes generated at the factories are sent to the treatment plant and the 800-degree centigrade incinerator. Most of the hazardous wastes including the toxic ash of the incinerator are either stored on site or dumped into the environment (The Dark Side of Petkim 2000 – Greenpeace document).

Technologies currently available for the production of chlorine and caustic soda are based on mercury-cell, diaphragm or membrane processes. Petkim's Aliaga chlor-alkali unit operated on mercury-cell process until July 2000. The management agreed with the Trade Union of Petroleum Workers to change the system to the mercury-free membrane process and eventually converted the system to membrane-cells in 2000 (The Dark Side of Petkim 2000 – Greenpeace document).

2. History of site

2.1 OWNERS OF THE FACILITY

Petkim is a firm which sustains its production using government support while continuing efforts to privatize. When law number 3291 came into effect on 28.05.1986, Petkim was added to the privatization program. For privatization purposes, Petkim was brought under the control of the Housing Development and Public Participation Administration. According to the Privatization High Council's decree, the Yarimca Complex, excluding lodging and social buildings, was taken over by Tüpras costing $60 million US. After the Privatization High Council's decree issued in Official Gazette, the transfer was completed on November 1, 2001.

Petkim's current directors' list is given below.

General Management

1 - Mustafa MUTLU - General Manager
2 - M. Sedat ERTUNÇ - Senior Assistant General Manager
3 - Abdulkadir TUNCER - Assistant General Manager (Operations)
4 - Serdar BILGI - Assistant General Manager (Privatization - Project)
5 - Yakup ATASEVEN - Assistant General Manager (Commercial)
6 - Akif AKÇA - Assistant General Manager (Administrative)
7 - Hayati ÖZTÜRK - Assistant General Manager (Financial)

Board of Directors

1 - Dr. Gökhan YAZICI - Chairman Of The Board
2 - Mustafa MUTLU - Vice Chairman / General Manager
3 - Hidayet KAYA - Member
4 - Prof. Dr. M. Ali GÜRKAYNAK - Member
5 - M. Sedat ERTUNÇ - Member
6 - Halit ÖCAL - Member
7 - M. Meray EKIN - Member
8 - Murat Ibrahim ÇELEBI – Member

2.2 PRODUCTION

The name plate capacities were reached in the production of ethylene, LDPE, benzene and PA and the highest production figures were obtained by the facility at the VCM and benzene products. See TABLE 1, 2. Capacity utilisation rates were 99% in ethylene, 94% in thermoplastics and 87% in the fiber intermediates productions (Petkim 2004).

Production Capacities TONS / YEARS

PRODUCTS	
THERMOPLASTICS	516,000
LDPE	190,000
HDPE	96,000
PP	80,000
PVC	150,000
FIBER RAW MATERIALS	249,000
ACN	90,000
PTA	70,000
MEG	89,000
OTHER PRODUCTS	799,000
ETHYLENE	400,000
BENZENE	123,000
PA	34,000
CHLORINE	100,000
VCM	142,000
TOTAL	1,564,000

Production TONS

PRODUCTS	CAPACITY	CAPACITY UTILIZATION %	GROSS PRODUCTION	FOR MARKETING
ETYHLENE	400,000	99	396,366	8
THERMOPLASTICS	516,000	94	483,817	477,517
PVC	150,000	93	139,974	139,974
LDPE	190,000	100	190,735	184,519
HDPE	96,000	86	82,213	82,129
PP	80,000	89	70,895	70,895
FIBER RAW MATERIALS	249,000	87	216,070	216,070
ACN	90,000	94	84,243	84,243
PTA	70,000	81	56,369	56,369
MEG	89,000	85	75,458	75,458
OTHER PRODUCTS	399,000	94	1,448,878	572,663
DEG			7,169	7,169
CAUSTIC SODA (%100)			100,022	86,871
PROPYLENE (CG)			87,824	
PROPYLENE (PG)			90,746	
VCM	142,000	89	126,721	
CHLORINE	100,000	86	85,785	
HCl (%27)			19,026	48
PA	34,000	98	33,347	33,347
BENZENE	123,000	106	130,358	130,358
o -X			33,504	
p - X			88,438	53,001
C5-PENTANE			71,187	71,187
C4			109,256	114,225
PY-GAS			278,391	8,394
AROMATIC OIL			63,840	61,054
MASTERBATCH			3,343	314
EDC			116,080	
PLASTIC MATERIALS			3,842	1,011
OTHERS (*)				5,684
GRAND TOTAL	1,564,000	94	2,545,131	1,266,258

(*) Low Polymer, Atactic Polymer, TEG, Sulphuric Acid and Hypochloride are marketable products.

TABLE 1, 2: Production Capacities of Aliaga complex in 2003
(Petkim Annual Report 2004)

2.3 MAJOR INVESTMENT PROJECTS

In the Rehabilitation of the VCM Plant the VCM production capacity has been increased from 142 000 tons/yr (2002) to 152 000 tons/yr (2003). A new incinerator and an acid recovery unit have been installed at the Aliaga complex by the firm.

In the second expansion of the Polypropylene Plant, production increased from 80 000 tons/yr to 144 000 tons/yr starting in 2001. Project completion is planned for 2005 (Petkim 2004).

The revamping and debottlenecking of the Low Density Polyethylene Plant is expected to increase the capacity from 190 000 tons/yr to 310 000 tons/yr. Construction work is progressing. The project is planned to be completed in 2005 (Petkim 2004).

In the expansion project of Ethylene (NSC) Plant the capacity is expected to be raised from 400 000 tons/yr to 520 000 tons/yr in order to meet the increased demand of ethylene needed in other expansion projects located in Aliaga Complex. In 2001 the bidding procedure started. The total completion of the project is planned for 2005 (Petkim 2004).

The progress of Petkim's 2003 Investment Program projects which are located at the Aliaga Complex are given below in TABLES 3a – 3b.

TABLE 3a : Aliaga Complex's major investment projects (1)
(PETKIM annual report 2004) Last Updated: May 20.2004

Investment project	**Project Cost (Million $)**	**Capacity Increase (Tons/Year)**	**Beginning - Completion Date**	**L : Licensor** **BE : Basic Engineering** **DE : Detailed Engineering** **P : Procurement** **SC : Site Contractor**
Chlor-Alkali Plant (Conversion to membrane cell technology)	31.5	20,000 chlorine (from 80,000 to 100,000) 22,000 caustic soda (from 90,000 to 112,000) 400 000 → brine	1998-2001	CEC - JAPAN (L,BE,DE,) CEC + PETKİM (P) PAKPAŞ İNŞ-TÜRKİYE (SC) MESSO-CHEMIE TECHNIK (BE,DE,P)
Addition of an oxy-chlorination line to VCM plan	13.8	15,000 EDC (Modernization of the whole unit)	1997-2000	VINNOLIT - GERMANY (L) KRUPP UHDE-GERMANY (BE,DE,P) ÇİLTUĞ A.Ş - TÜRKİYE (SC)
Addition of a second 20 MW condensing type turbo generator to the power plant / addition of cooling tower	12.1	56 MW (from 95 MW to 151 MW)	1997-2001	ABB - SWEDEN (BE,DE,P) SETA İNŞ - TÜRKİYE (SC) / SPIG - ITALY (BE,DE,P) EREN İNŞ- TÜRKİYE (SC)
Addition of 17th reactor to the 4th Production line of PVC plant	0.8	10,000 (from 140,000 to 150,000)	1998-2001	SOLVAY – BELGIUM (L) PETKİM (BE,DE,P) TERBAY A.Ş.-TÜRKİYE (SC)
2nd expansion of HDPE plant	18.5	30,000 (from 66,000 to 96,000)	1998-2001	MITSUI CHEM- JAPAN (L,BE) LURGI - GERMANY (DE,P) ÇOLAKOĞLU İNŞ-TÜRKİYE (SC)
Addition of a new liquid-solid waste treatment unit and modernization of the existing unit	20.2	Incineration of 17,500 T/Y waste, 11.5 tons/ hour steam generation	1999-2002	VINCI (SGEE) – FRANCE (BE,DE,P) SİSTEM YAPI-TÜRKİYE (SC)
VCM plant rehabilitation and HCl production	19.8	10,000 (from 142,000 to 152,000)	1999-2003	VINNOLIT - GERMANY (L) KRUPP UHDE -GERMANY (BE, DE, P) PASİNER-TÜRKİYE(SC)

TABLE 3b : Aliaga Complex's major investment projects (PETKIM annual report 2004)

Investment project	Project Cost (Million $)	Capacity Increase (Tons/Year) 6	Beginning - Completion Date	L : Licensor BE : Basic Engineering DE : Detailed Engineering P : Procurement SC : Site Contractor
Expansion of the water pre-treatment unit	5.2	3,000 m^3/hour (from 4,500 m^3/hour to 7,500 m^3/hour)	1999-2004	OTV - FRANCE / HIDRO OTV - TÜRKİYE (BE,DE,P) AKFEN-TÜRKİYE (SC)
Expansion of ethylene plant	82.0	120,000 (from 400,000 to 520,000)	1999-2005	S&W – U.KINGDOM (L, BE) IFP (FRANCE (L,BE)(C3-C4 H.) MITSUI ENG.-JAPAN+GAMA TR (LUMP SUM TURNKEY)
Addition of 3rd production line to LDPE plant	65.0	120,000 (from 190,000 to 310,000)	1999-2005	DSM - STAMICARBON - HOLLAND (L, BE) TECHNIP - FRANCE (DE, P) TOKAR-TÜRKİYE (SC)
2nd expansion of PP plant	25.6	64,000 (from 80,000 to 144,000)	1999-2005	MITSUI CHEM-JAPAN (L,BE) MITSUI ENG.(MES)- JAPAN (DE,P)
Rehabilitation of cooling water system	12.3	Capacity increase of the existing cooling water system	2001-2005	SALINE WATER SPEC.- ITALY(DE,P) ALKE+MARSİS-TÜRKİYE (SC)
Rehabilitation of demineralized water system	5.1	Capacity increase of the existing demineralized water system	2001-2005	OTV-France (BE,DE,P)
Debottelenecking of steam generation unit	48.1	Capacity increase of the existing boilers and modification of nat. gas in addition to fuel oil	2001-2008	
TOTAL	**363.6**			

3. Chemical characterization and Environmental / Health Consequences

3.1 PVC and its additives

Polyvinyl chloride (PVC) is one of the most widely used thermoplastics in the world, with an annual global production of about 25 million tonnes (CIN, 2003). PVC can be produced through a number of different processes. Currently, the majority of facilities employ processes using the ethylene dichloride (EDC) intermediate (Matthews, 1996).

Ethylene dichloride (EDC) is manufactured by the chlorination of ethene, either directly with chlorine or through an oxychlorination process using hydrogen chloride and oxygen. Vinyl chloride, also called vinyl chloride monomer (VCM), is then produced from EDC (Stringer & Johnston, 2001). Subsequently, VCM is polymerised to produce PVC. The production of VCM and its polymerisation into PVC are not always carried out at the same facility.

The manufacture of EDC and VCM results in the generation of toxic chlorinated wastes containing dozens of hazardous chemicals, including chlorinated dioxins. The environs of many VCM production facilities are often contaminated with many of these chemicals (Labunska *et al.,* 2002; Stringer & Johnston, 2001; Stringer *et al.,* 1995).

PVC formulations typically contain a range of additional chemicals that are incorporated to modify the properties of the plastic (Ehrig, 1992). These additives include plasticisers to soften the PVC for non-rigid applications, stabilisers to combat UV and heat-induced degradation, and pigments to colour the plastic. A wide range of synthetic organic chemicals and heavy metal compounds are employed as such additives (Stringer & Johnston, 2001).

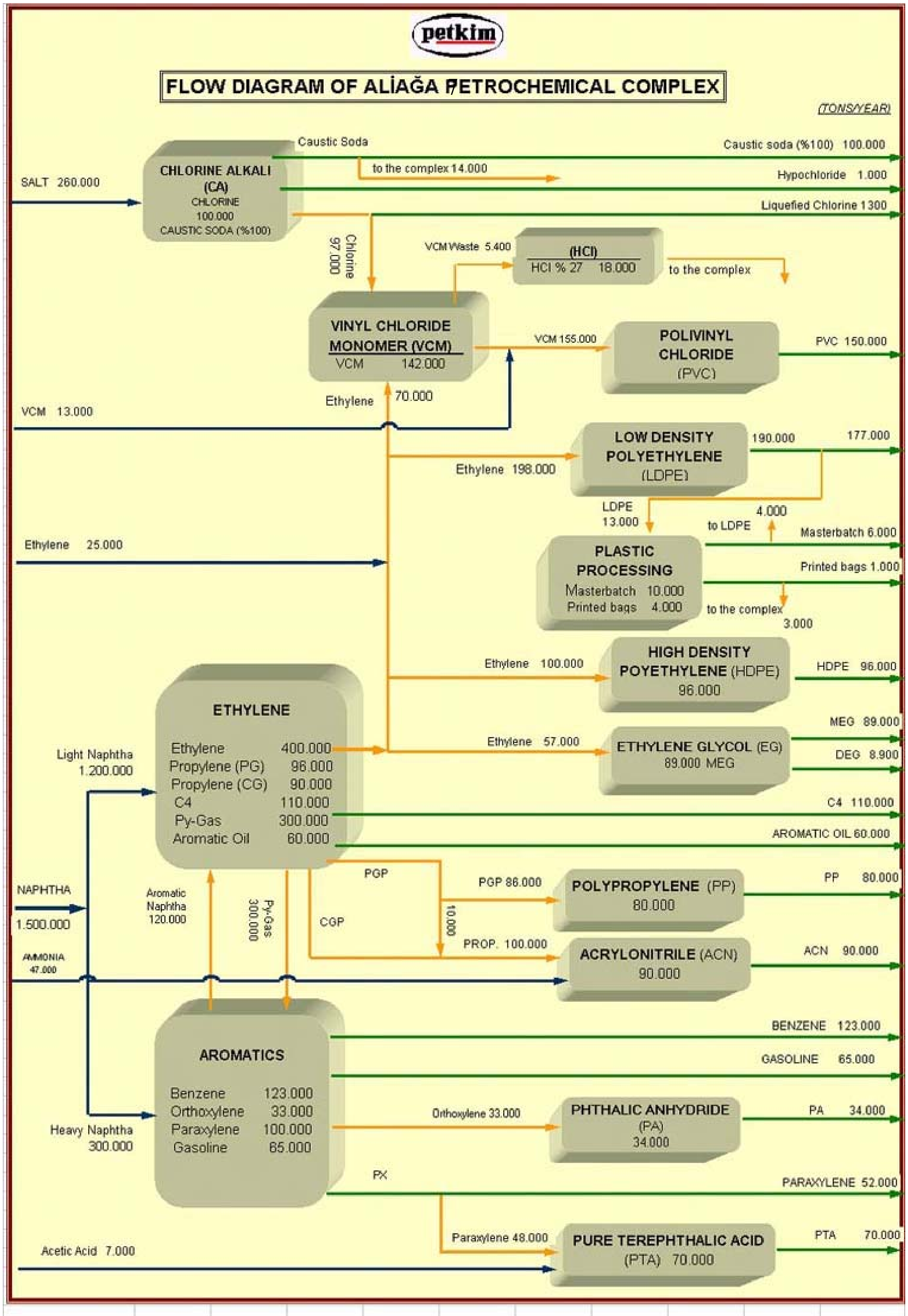

FIGURE 4: Petkim 's flow chart (Petkim 2004)

3.1.1 Lead compounds

Lead compounds used as stabilisers can be released from the product, causing concern because of the toxicity of the lead, especially to children. In the US in 1996, numerous newspaper reports told of window blinds being removed from the market after the discovery that sunlight caused the PVC to degrade and release lead. It was thought that the lead dust could be particularly hazardous to children under the age of six. A year later, lead was found in PVC children's products in the US and Canada.

Lead may also be released from the plastic during its recycling or disposal, though this subject has not been extensively researched.

3.1.2 Cadmium compounds

Cadmium is a highly toxic metal that is used to stabilise PVC in some applications and also as a pigment in PVC and other applications (Tamaddon & Hogland, 1993). Window frames are frequently stabilised with cadmium compounds (Matthews, 1996). Cadmium use in plastics has been banned in Sweden (Tamaddon & Hogland, 1993) and restricted in Switzerland and the EU for environmental reasons (Vollrath *et al*., 1992). PVC is the only plastic in which cadmium is used as a stabiliser (Tamaddon & Hogland, 1993).

3.1.3 Chlorinated paraffins

Chlorinated paraffins are frequently used in PVC coating for electrical cables; when present they tend to represent 10% by weight of the PVC formulation (Matthews, 1996). Chlorinated paraffins are ecotoxic compounds which have been recognised as highly persistent in the environment, bioaccumulative and transported globally from the point of release (see e.g. Svanberg, 1983). The Oslo and Paris Commissions agreed in 1996 to phase out long chain chlorinated paraffins in Northeast Atlantic countries.

3.1.4 Antimony compounds

Antimony trioxide is used as a flame retardant. It is toxic and suspected of being carcinogenic (Matthews, 1996).

3.1.5 Phthalate plasticisers

The phthalate esters are a family of compounds which are the most widely used PVC softeners (Bizzari *et al*., 1996). They are the most abundant man-made chemicals in the environment (Jobling *et al*., 1995). They can bioaccumulate to some degree, predominantly from food. They also exhibit a variety of toxic effects, based on research in animals.
Some phthalates can cause cancer in animals and the most common one, DEHP – di (2ethylhexyl) phthalate or bis (2ethylhexyl) phthalate, has been classified as possibly carcinogenic to humans by the IARC (IARC, 1987; ATSDR, 1993b; European Commission, 1996). Some can also affect the liver (Chan & Meek, 1994; ATSDR, 1990& 1995b; Swedish National Chemicals Inspectorate (KEMI), 1994); the kidneys (Chan & Meek, 1994; ATSDR , 1990 & 1993b) and irritate the eyes (ATSDR, 1995b).

Individual phthalates can harm the male reproductive tract (Chan & Meek, 1994; ATSDR, 1995b & 1993b); the female reproductive tract (Chan & Meek, 1994; Ema *et al.,* 1994; ATSDR, 1993b); impair reproductive success (Chan & Meek, 1994; Ema *et al*., 1994 & 1995; ATSDR, 1990, 1993b & 1995b) and cause teratogenicity (malformation of the offspring) (Ema *et al.*, 1993 & 1995; Chan & Meek, 1994; ATSDR, 1993b & 1995b).

Because of concern about the toxicity of the phthalate plasticisers and their use in products used for children, Greenpeace analysed teethers and other toys from a number of countries. According to analysis, these substances contained high levels of phthalates, as much as 40% in some items (Stringer *et al*., 1997 & 2000), in addition to a wide range of other additives and contaminants, many of which simply could not be identified. Other researchers found that unacceptable concentrations of some of the phthalates could leach from some of the toys, and certain PVC toys have been removed from sale in a number of European countries (see e.g. MacKenzie, 1997). In December 1999, the EC instituted a three-month ban on the sale of products intended to be placed in the mouth by children under three years of age, which contained more than 0.1% of six specific phthalates (Decision 1999/815/EC) (EC 1999a). This ban was renewed nineteen times and in 2004, EU ministers voted unanimously to make it permanent by amending Directive 76/769/EEC. Another suspected source of harm to people - particularly children - is from breathing in phthalates. Other research has suggested that atmospheric DEHP could play a role in asthma in children (Oie *et al*., 1997).

3.2 Chlor alkali process

This process is used to manufacture sodium hydroxide and chlorine gas. Sodium hydroxide is a widely used bulk chemical. Chlorine and its uses are described in more detail below. (There are three main chloralkali processes. At its Aliaga plant, Petkim has used the most polluting technology – the mercury cell- until July 2000.)

3.2.1 Chlorine and organochlorines

Apart from PVC, chlorine is also used to manufacture thousands of organochlorine products. Organochlorines are materials based on carbon and chlorine. Initially regarded as a technological advancement, many have been restricted or banned because of their potential harm to human health and the environment. The most notorious of the organochlorines include the insecticide DDT, ozone depleting CFCs, chlorinated solvents including dry cleaning fluids, PCB transformer fluids, and dioxins and furans, which are the world's most toxic organic pollutants. PVC and its precursors ethylene dichloride and vinyl chloride are all organochlorines.

3.2.2 Ethylene dichloride and vinyl chloride

Once the necessary chlorine has been produced, the next stage of PVC manufacture is to make ethylene dichloride (EDC). This is then converted into vinyl chloride, which is the basic building block (monomer) for PVC. EDC can be produced by oxychlorination or by direct chlorination. In the direct chlorination method, ethylene is reacted with chlorine to produce EDC. Oxychlorination produces EDC by reacting ethylene with dry hydrogen chloride and oxygen (ATSDR, 1995a).

To produce vinyl chloride (VC), EDC is subjected to high pressures and temperatures. This causes the EDC to undergo pyrolysis (also called thermal cracking), which yields vinyl chloride monomer and hydrogen chloride (The Dark Side of Petkim 2000 – Greenpeace document).

Both ethylene dichloride and vinyl chloride monomer are hazardous chemicals. Their production also results in the generation of toxic chlorinated wastes containing dozens of hazardous chemicals. This waste also contains dioxins, some of the most toxic chemicals produced by modern industry.

3.2.2.1. Ethylene dichloride

Ethylene dichloride is a colourless, volatile liquid with a pleasant smell. Its proper chemical name is 1,2-dichloroethane, but it is more commonly called ethylene dichloride or EDC. It will not persist very long in the environment but is both hazardous and toxic. It is highly flammable and may pose an explosion hazard.

Because of its volatility, the most usual route of exposure is via inhalation. However, it can also cause harm through skin contact or eye contact. It is one of the more toxic chlorinated solvents via inhalation. At high concentrations, it can upset the nervous system and gastrointestinal system, causing dizziness, nausea, and vomiting. US EPA classifies it as a probable human carcinogen. The liver, 10
kidney, and adrenal gland may also be damaged. EDC can be toxic at concentrations too low to be detected by smell (Snedecor, 1993).

3.2.2.2 Vinyl chloride

Vinyl chloride is a colourless gas at normal temperatures. It is also known as chloroethene, chloroethylene, ethylene monochloride, or monochloroethylene. It is flammable (burns easily) as a gas and is not stable at high temperatures. Vinyl chloride exists in liquid form if it is kept under high pressure or at low temperatures (less than –13.4°A). Vinyl chloride has a mild, sweet odor. Most people begin to smell vinyl chloride in the air at 3,000 parts vinyl chloride per million parts (ppm) of air. However, the odor is of no value in preventing excess exposure. Most people begin to taste vinyl chloride in water at 3.4 ppm. Vinyl chloride is classified by US EPA as a known human carcinogen.

All vinyl chloride is manufactured or results from the breakdown of other manufactured substances, such as trichloroethylene, trichloroethane, and tetrachloroethylene.
Most of the vinyl chloride that enters the environment comes from the plastics industries, which release it into the air or into wastewater. EPA limits the amount that industries may release. Vinyl chloride is also a breakdown product of other synthetic chemicals in the environment. Vinyl chloride has entered the environment at hazardous waste sites as a result of its improper disposal or leakage from storage containers or from spills, but some may be from the breakdown of other chemicals. Liquid vinyl chloride evaporates easily into the air. Vinyl chloride in water or soil evaporates rapidly if it is near the surface. Vinyl chloride in the air breaks down in a few days. When vinyl chloride breaks down in air, it can form other harmful chemicals. A limited amount of vinyl chloride can dissolve in water. It can enter groundwater and can also be found in groundwater from the breakdown of other chemicals. It is unlikely that vinyl chloride will build up in plants or animals that you might eat.

3.2.2.3 Other chlorinated and non-chlorinated pollutants

Although dioxins are the most notorious and best researched pollutants found in PVC industry wastes, there are literally hundreds of other pollutants mixed in with them. These may be released into the environment in a number of ways, including into the wastewater emitted from the plant. Since 1996, Greenpeace has analysed samples of wastes, wastewater and sediments from the Aliaga sites and its immediate environment. This includes samples from the on-site incinerator, sediment from the bay, and samples taken from an apparently uncontrolled dumpsite in the plant area near the coast. The table below (**TABLE 4**) lists the chlorinated pollutants found in these samples and identified with a certainty of more than 90% by computer-based mass spectral matching techniques.

TABLE 4 : Organochlorine pollutants identified in environmental and waste samples taken from the site and vicinity of the Aliaga Petkim site since 1996 (Source : Petkim 2004)

1,1,2,3,3-Pentachloro-1-propene	Benzene, chloro(2-chloroethyl)-
1,1'-Biphenyl, 2,2',3,3',4,4',5,5',6-nonachloro-	Benzene, hexachloro-
1,1'-Biphenyl, 4-chloro-	Benzene, pentachloro-
1,3-Butadiene, 1,1,2,3,4,4-hexachloro-	Benzene, pentachloro(trichloroethenyl)-
1,3-Butadiene, 1,1,3,4-tetrachloro-	Benzenemethanol, 4-chloro-3-nitro-
1,3-Butadiene, pentachloro-	Butane, 1,2,3,4-tetrachloro-
1,3-Cyclopentadiene, 1,2,3,4,5,5-hexachloro-	Chloroform
1-Butene, 1,4-dichloro-	Chloromethyldiphenylmethane
1-Butyne, 3-chloro-	Ethane, 1,1,2,2-tetrachloro-
1-Propene, 3,3,3-trichloro-2-methyl-	Ethane, 1,1,2-trichloro-
1-Propene, pentachloro-	Ethane, 1,2-dichloro-
2,2-Chlorophenyl-1,1-dichloroethylene	Ethane, hexachloro-
2-Butene, 1,4-dichloro-	Ethane, pentachloro-
Benzene, (2-chloroethenyl)-	Ethene, tetrachloro-
Benzene, (2-chloroethyl)-	N-(3'-Chlorophenyl)-2-hydroxyimino acetamide
Benzene, 1,2,4-trichloro-	o,p'-DDT
Benzene, 1,2-dichloro-	Octachloropentafulvalence
Benzene, 1,4-dichloro-	Octadecane, 1-chloro-
Benzene, 1-chloro-2-(1-chloroethyl)-	Phenol, 4-amino-2,6-dichloro-
Benzene, 1-chloro-2-ethyl-	Phenol, 4-chloro-5-methyl-2-nitro-
Benzene, 1-chloro-2-methyl-	Propane, 2-bromo-1-chloro-
Benzene, 1-chloro-3-ethyl-	Propane, 3-chloro-1,1,1-trifluoro-
Benzene, 1-chloro-4-ethyl-	Sulfone, chloro phenyl
Benzene, chloro-	

Hydrocarbon chemicals, consistent with petrochemical production, were again predominant. The likely source was in the Aliaga complex's sample of sediment collected immediately offshore from another facility of the firm, Yarimca Petkim complex, in 1999. It is possible that the production of polystyrene and butadiene rubbers at the Petkim plant is partly responsible, although the predominant source of these contaminants would appear to be refinery operations. The sample also contained hexa- and pentachlorobenzene, undoubtedly a reflection of the chlorine chemistry being undertaken within, or in the vicinity of, the plant. In this regard, it is worth noting that the production of EDC and VCM leads not only to the incidental synthesis of chlorinated dioxins, dibenzofurans, and PCBs, but also of various other persistent organic pollutants including penta- and hexachlorobenzene. It is probable also that the high hydrocarbon content of the sediment would have acted to obscure some other chlorinated chemicals potentially present from the chlorine chemistry-based operations on the site.

3.3 EDC / VCM WASTES

Wastes from the production of EDC/vinyl chloride 11
are complex and variable in nature. "Light ends" from the purification of EDC are volatile liquids, whereas "heavy ends" or EDC tars are thick black liquids. Many of these wastes will be contaminated with dioxins. ICI, for many years the UK's major EDC and vinyl chloride manufacturers, stated that the oxychlorination process inevitably produced dioxins (ICI, 1994). Many other pollutants may also be present in the wastes.

3.3.1 Dioxins and furans

3.3.1.1 DIOXINS

Dioxins are persistent organic pollutants (POPs), one of a number of synthetic chemicals and chemical groups that can cause severe, long term impacts on wildlife species, whole ecosystems and human health.

The terms “dioxin” or “dioxins and furans” generally refers to a group of 210 chlorinated pollutants, the polychlorinated dibenzo-p-dioxins and dibenzofurans. They are widely regarded as the most toxic organochlorine pollutants. They are also highly persistent in the environment. They have always been produced naturally in very small quantities. However, in modern times, they have also been produced as byproducts of industrial processes involving chlorine.

In addition to being highly persistent in the environment, dioxins and furans are fat soluble. Consequently, they build up in the bodies of animals and remain there for many years. Every person alive is exposed to dioxins on a daily basis. Workers of the PVC and chlorine production plants may be exposed to these highly hazardous chemicals yet more frequently.

The most toxic of the 210, 2,3,7,8-tetrachlo-rodibenzo-p-dioxin (2,3,7,8- TCDD), is used as the toxicological model for the group and has been very extensively researched. There are 17 dioxins and furans that have the 2,3,7,8-chlorine substitution and consequently act through the same biochemical mechanism. Their toxicity is rated against that of 2,3,7,8-TCDD and each compound is given a toxicity equivalence factor (TEF). This system allows the scientist to estimate the total toxicity of the mixes of dioxins and furans as a 2,3,7,8,-TCDD toxicity equivalent (TEQ). Analytical results for dioxins are therefore usually expressed in terms of the TEQ.

2,3,7,8-TCDD has been classified in group 1 (carcinogenic to humans) by the International Agency for Research on Cancer (IARC) (IARC, 1997). The WHO has recently re-evaluated the tolerable daily intake (TDI) of dioxins and furans for the ordinary population. They recommended that the TDI be reduced from 10 pg/kg body weight/day to 1 to 4 pg/kg body weight. They also recognised that background exposure in developed countries is higher than this TDI, being 2 to 6 pg/kg body weight/day and recommended that every effort should be made to reduce exposure to the lowest level (WHO, 1998; van Leeuwen & Younes, 1998).

The most extensive review of the toxicity of 2,3,7,8-TCDD was conducted by the US Environmental Protection Agency (US EPA) and published in draft form in June 2000 (US EPA, 2000). The EPA concluded, like the IARC, that 2,3,7,8-TCDD can be described as a human carcinogen. It found that in addition to causing cancer, evidence from human and animal studies demonstrates that dioxin could damage the nervous system, the immune system, and the reproductive system (including reducing sperm count). It could cause malformations in the unborn, disrupt the endocrine system, and cause a number of other harmful effects.

Most importantly, the draft review concluded that some of the more sensitive non-cancer effects could be occurring at the levels of exposure that are experienced by ordinary men and women. Moreover, calculations based on the available data also indicate that exposure to dioxin could be causing cancer in between 1 in 100 and 1 in 1000 people (EPA, 2000). Since dioxins are very poorly soluble in water, they will only be present in aqueous effluents in very low concentrations. However some of the wastes from the PVC industry can contain high concentrations of dioxins.

Industrial sources of dioxins include:

- incineration of medical and municipal waste, incineration of sewage sludge and of hazardous industrial wastes
- PVC plastics manufacture and disposal
- pulp and paper bleaching processes using chlorine and chlorine chemicals
- metal smelting and refining

3.4 Data generated by NGOs

3.4.1 GREENPEACE’S ANALY-SIS

Since 1996, Greenpeace has analysed samples of waste, wastewater and sediments from the Aliaga sites and its immediate environment. This includes samples from the on-site incinerator, sediment from the bay, and samples taken from an apparently uncontrolled dumpsite in the plant area near the coast. The Petkim samples contain a number of chemicals listed for control under the North Sea Ministerial Declaration (MINDEC, 1990) and the Barcelona Convention Strategic Action Programme to address pollution from land-based activities (UNEP,1995).

Two isomers of the PCBs are also identified (2,2’,3,3’,4,4’,5,5’,6-nonachloro-1,1’-biphenyl and 4-chloro-1,1’-biphenyl). It is impossible to tell what the source of these congeners is, but it is possible that they, like the dioxins, are byproducts of the chemical reactions taking place during synthesis and purification of EDC and VCM.

3.4.1.1 Dioxins

In 1997, Greenpeace analysed a sample of Petkim Aliaga waste for dioxins and found a total amount of dioxin of 56.94 μg ITEQ/kg dry wt. See **TABLE 5**.

TABLE 5 : Results of dioxin analysis of waste from Petkim (Source: The Dark Side of Petkim 2000 –Greenpeace Document)

	Toxicity Factors ITEF	Reported results (ug/kg dry wt)	Toxicity Equivalents (ITEQ) (ug/kg dry wt)
Dioxins			
2378-TCDD	1	0	0
12378-PeCDD	0.5	0.34	0.17
123478-HxCDD	0.1	0.39	0.039
123678-HxCDD	0.1	0.34	0.034
123789-HxCDD	0.1	0.33	0.033
1234678-HpCDD	0.01	4.9	0.049
OCDD	0.001	25	0.025
Furans			
2378-TCDF	0.1	1.4	0.14
12378-PeCDF	0.05	22	1.1
23478-PeCDF	0.5	4.9	2.45
123478-HxCDF	0.1	190	19
123678-HxCDF	0.1	51	5.1
123789-HxCDF	0.1	48	4.8
234678-HxCDF	0.1	12	1.2
1234678-HpCDF	0.01	1200	12
1234789-HpCDF	0.01	240	2.4
OCDF	0.001	8400	8.4
		Total ITEQ	**56.94 ug/kg dry wt**

The sample from Petkim must be regarded as extraordinarily contaminated. As an example, the US EPA (US EPA, 1994b) summarised all the available data for soils in the US and Europe. They found that in the US, a background soil sample, with no particular industrial contamination, contained on average, 8 ng/kg TEQ PCDD/F. In Europe, the average figure was 9 ng/kg TEQ.

The dioxin contamination seen in Aliaga is typical of that from PVC factories – it contains the same "fingerprint" of different dioxin and furan congeners seen at other PVC factories (see e.g. ICI, 1994; Wenning, 1992), with a very high proportion of higher chlorinated dibenzo-furans. Greenpeace and other researchers have analysed samples associated with VCM or PVC manufacture. The data demonstrates that the waste collected from Petkim is among the most contaminated samples recorded from this industry (**TABLE 6**).

TABLE 6: Dioxin contamination of Petkim wastes compared to other PVC related Wastes from around the world

Sample type	VCM/PVC producer	Country	ITEQ (ng/kg)	Sample number and reference
mussel	Enichem	Italy	6.89	MI 5123/ Greenpeace data
sediment	Geon Goodrich	USA	15.42	PU4033/ Greenpeace data
organic waste	Borden	USA	329	MI6049/ Greenpeace data
sediment	Akzo	Netherlands	433	J2/ Wenning *et al.* 1992
sediment	Akzo	Netherlands	683	J5/ Wenning *et al.* 1992
sediment	Akzo	Netherlands	715	J1/ Wenning *et al.* 1992
sediment	Enichem	Italy	753.5	MI5021/ Greenpeace data
sediment	Akzo	Netherlands	835	J4/Wenning *et al.* 1992
sediment	Akzo	Netherlands	922	J3/ Wenning *et al.* 1992
organic waste	Formosa Chemicals	USA	3192	PU4043/ Stringer *et al.* 1995/ Greenpeace data
organic waste	ICI	UK	7561	MOPS VH/2A ICI 1994
sediment	ICI	UK	12286	MOPS/L1/1A ICI 1994
organic waste	EVC	UK	16530	UK6003/ Greenpeace data
organic waste	Georgia Gulf	USA	19978	PU4016/ Stringer *et al.* 1995/ Greenpeace data
sediment	Aiscondel	Spain	48000	MI5059/ Greenpeace data
sludge	**Petkim**	**Turkey**	**56940**	**MI4047/ Greenpeace data**
sludge	PPG	USA	76239	MI6051/ Greenpeace data
organic waste	Vulcan Chemical	USA	6370000	PU4017/ Stringer *et al.* 1995/ Greenpeace data

3.4.1.2 Mercury

Because of the concern about mercury, Greenpeace has conducted surveys of mercury in and around the
13 Aliaga Petkim plant. Environmental samples demonstrate contamination with mercury, and effluent samples confirm that Petkim is the source (**TABLE 7**).

TABLE 7: Results of mercury concentration analysis of samples taken from Petkim by Greenpeace (source: Dark Side of PETKIM report 2000—Greenpeace Document)

Sample number	Date	Location of sample	Mercury concentration
Aliaga			
Aqueous samples			**ug/l**
MI6152	24-9-96	Outfall 1	<2
MI6153	24-9-96	Adjacent to outfall 2	255
Solid samples			**mg/kg dry wt**
MI6147	23-9-96	Banks of effluent canal, outfall 1	1137.0
MI6148	23-9-96	10-15m from outfall 1	513.9
MI6149	23-9-96	10-15m from outfall 1	459.2
MI6150	23-9-96	20-25m from outfall 2	403.4
MI6151	23-9-96	20-25m from outfall 2	409.8
MI8007	01-5-98	Coastal dump site	0.3
MI8009	01-5-98	Coastal dump site	7.1
MI8010	01-5-98	Coastal dump site	1.4
MI8015	01-5-98	Coastal dump site	2.9

Sea water sampled adjacent to outfall 2 contained 255 µg/l of mercury - over five times the EU limit. Sediments collected near the outfalls contained up to 2,000 times published back-ground concentrations (Bryan & Langston, 1992).

To investigate the mercury exposure of workers at Aliaga, Greenpeace conducted analyses of human hair in 1997 (Stephenson, 1997). Hair is regarded as a good biomarker of long term exposure to mercury, including occupational exposures (ATSDR, 1993a; WHO, 1990).

Samples were taken from 54 men who worked at different sites in the factory **(FIGURE 5**).

Mercury levels in the hair of the chlor-alkali-workers sampled range from 0.2 to 18.6 mg/kg, with a mean value of 2.25 mg/kg. Control samples taken from individuals both in Turkey and the UK were at the extreme low end of the results for this study.

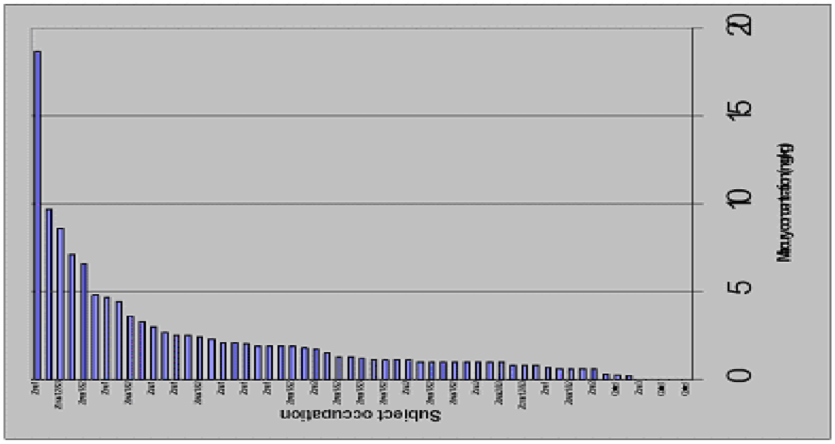

FIGURE 5 : The concentrations of mercury found in individuals working at different sites at the Aliaga plant in 1997.

4. Responsible party

The Stockholm Convention lists dioxins, furans, PCBs, and HCB for reduction and elimination and all are associated with the PVC lifecycle. The additives used for plasticising and the softening agents are highly ecotoxic. Burning PVC and the products that include additives used in the production of PVC can cause dioxin and furan exposure. These incineration products can be biocumulative in living organisms, causing serious health effects such as liver cancer and the other types of cancers. The list of potential effects can be longer, including damage to immune system, reproductive system, nervous system, endocrine system, and malformation in the unborn.

Turkey signed the Stockholm Convention in 2001 but has not yet ratified the Treaty. To reduce and eliminate POPs associated with Petkim and other sources, Turkey should ratify the Stockholm Convention as soon as possible. Regulations should be rearranged immediately, and environmental laws should be examined for sufficient and detailed information. The articles of the Stockholm Convention must be executed by the government as soon as possible.

5. Plans for cleanup

The firm has plans for modernizing waste treatment units by using new technologies continuously, increasing the capacity and the working sensitivity by additional investments. In the Aliaga plant, the firm was using the mercury cell process until the year 2000. 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.

On the other hand, Petkim has formed an "Environment Team" in the Aliaga Complex consisting of a chemical engineer, 3 environmental engineers and 30 site workers. The Environment Team is responsible for inspection and implementation of the Aliaga Complex environmental activities, according to environmental regulations.

However, the team's measurement of liquid and gas emissions is not periodical. In addition to this, atmospheric gas measurement, drinking water analysis, noise measurement, effluent gas measurement and waste water analysis are made. But the given numbers are not reliable. To prevent visual pollution, cleaning of waste water canals and plant areas and inspection of the temporary solid waste storage area are carried out, but these efforts are inefficient and irregular.

Petkim's existing treatment units are:

- Pretreatment Units for liquid and gas emissions of process plants
- Waste Treatment Unit to provide discharge of waste water according to "Water Pollution Control Regulations", sludge incinerators to burn sludge, liquid and oil waste from process plants
- Treatment units, 2 separate incinerators to incinerate hazardous wastes and 7 flare to burn residual gas.

6. Recommendations of NGOs

There are currently over 150 million tonnes of long-life PVC materials in existence globally (Greenpeace International website - 1998). Most of these are used in the construction sector and will constitute a waste mountain in coming decades. With the current rate of production the world will have to deal with approximately 300 million tonnes of PVC starting to enter the waste stream by the year 2005. The amount of PVC waste in industrialised countries is already expected to grow faster than PVC production.

Of even more concern is the fact that the PVC industry is rapidly expanding in Latin America and Asia, so that eventually a growing waste mountain will be generated in these parts of the world.

In light of the large volume of long-life PVC products due to become waste in the coming decades, and the projected increase in PVC production, it becomes apparent that an international PVC phase-out is urgently required. Only this will put a halt to a growing, dangerous and intractable waste problem.

Since PVC, like most plastics, does not biodegrade quickly, three primary options exist:

1) bury
2) incinerate
3) recycle.

6.1 PVC recycling

In the late '80s, PVC recycling was promoted by the industry in order to make it more acceptable to the public and to prevent government action to limit PVC production and use.

As a result, the general public and decision-makers are now accepting recycling as a technical solution to the environmental problems associated with PVC. This is especially the case in countries with advanced recycling policies, like Denmark, Germany, the Netherlands and the US.

In reality, Greenpeace has found that PVC recycling in the primary PVC-consuming regions of the world, amounts to less then one percent of consumption. According to independent research, for 70 to 85 percent of PVC waste, recycling is not even an option for the mid to long term. This means hundreds of thousands of tonnes of PVC is destined

to become waste in the near future, creating a growing disposal problem.
Our research also shows that, in an attempt to convince the public and decision-makers that PVC can be and is being recycled, the PVC industry is supplying false information. For example, in Germany, so-called 'recycled' window frames, promoted by the industry as proof that old PVC windows are being recycled into new window frames, were tested by Greenpeace. None of the seven tested samples were really recycled window frames. Subsequent testing showed they only contained pre-consumer PVC waste from leftovers, and they had been coloured to resemble a recycled window frame. Only two contained traces of recycled PVC from used window frames and even these were insignificant.
A tour of highly publicised PVC recycling plants revealed that hardly any PVC construction material was being processed at all. This is because it is difficult and costly to collect, and there is little market for recycled products due to the cheap price of virgin PVC products.

6.2 PVC plastic waste is difficult and expensive to manage

A major problem in the recycling of PVC is its high chlorine content of raw PVC (56 percent of the polymer's weight) and the high levels of hazardous additives added to the polymer to achieve the desired material quality. Additives may comprise up to 60 percent of a PVC product's weight. Of all plastics, PVC uses the highest proportion of additives. As a result, PVC requires separation from other plastics and sorting before mechanical recycling. For this reason, PET bottle recyclers make sure that PVC bottles do not contaminate their mix.
PVC recycling is particularly problematic because of:

- high separation and collection costs
- loss of material quality after recycling
- the low market price of PVC recyclate compared to virgin PVC
- the limited potential of recyclate in the existing PVC market

PVC feedstock recycling is hardly feasible at present, from an economic or an environmental perspective. It is doubtful whether it will ever play a significant role in PVC waste management. The PVC industry seems to acknowledge that PVC recycling is no solution for PVC waste. Therefore it is not surprising that the industry is now lobbying for PVC incineration as a recovery option (for energy, hydrochloric acid and/or salt) in Western Europe and Japan and for land filling in the US and Australia. This forces local authorities to shoulder the burden of pollution and costs from PVC consumption.

6.3 PVC and incineration

Incineration is not a sustainable option for dealing with waste. When plastic is burned, less energy is generated from it than was used to make it. Incineration also means that the carbon contained within it is emitted as carbon dioxide (CO_2), which is a greenhouse gas. Toxic substances, such as dioxins, are also emitted, and large amounts of solid wastes are produced such as slag, ash, filter residues and neutralisation salt residues. The higher the chlorine content of the materials burned, the greater the quantity of dioxins formed. In many countries, PVC is the single largest chlorine source in municipal waste. Research has shown an association between chlorine input and dioxin output in hospital and municipal garbage incinerators.
Incineration of PVC is not just a problem because of dioxin emissions. Burning PVC also produces at least 75 by-products of combustion, including carcinogens such as vinyl chloride, Polychlorinated Biphenyls (PCBs), chlorobenzene and other aromatic hydrocarbons such as benzene, toluene, xylene, and naphthalene.
Toxic ingredients added to PVC to give it useful properties, such as lead, cadmium, and phthalates, are also released during incineration. These are emitted into the air or the ash that is land filled. Because huge quantities of heavy metals are added to PVC as stabilisers, PVC is the major source of lead and cadmium in the municipal waste stream. In Germany, PVC incineration releases more lead into the environment than leaded gasoline, and is considered the main source of cadmium emissions.
Incinerating PVC increases the amount of hazardous waste that needs to be land filled. The incineration of 1 kg of PVC creates approximately 1 to 3 kg of contaminated salt residues. This is due to the neutralisation of the hydrochloric acid when dry and semi-dry neutralisation processes are applied. This salt needs to be disposed of in landfills as hazardous waste, making a mockery of the claim that incineration is a form of waste reduction.
In Germany, the Council of Experts for Environmental Issues issued a special report on waste management in 1990 concluding:
"*Even assuming the possibility and technical implementation of pollution free PVC incineration by means of end of pipe measures, it will remain necessary to remove the hydrochloric acid that is formed from the flue gas, to bind it as a salt and to store it....therefore the waste volume to be stored cannot be reduced by means of incineration.*"

6.4 PVC and landfills

PVC additives will eventually leach, posing a risk to groundwater. The bulk of petrochemical-based plastics, such as PVC, polypropylene (PP) and polyethylene (PE) are durable and have a long lifetime. After disposal, they do not decompose readily or quickly.

Moreover, the use of many different chemical additives in some plastics results in their leaching out of landfills to contaminate soil and groundwater. This is especially true for PVC, which has the highest content of additives, most of which are hazardous to the environment.

Considerable quantities of PVC are present in landfills, as a result of the disposal of municipal solid wastes (MSW), and construction and other wastes. Almost one million tonnes of PVC went to landfills in Europe as MSW in 1994. PVC waste from other sectors, such as agriculture, the car industry, construction and distribution, was not included and will add considerably to this figure.

Landfill fires become particularly toxic with PVC waste. Landfill fires are a common occurrence, with the potential to pyrolyse and combust PVC, leading to the release, either in smoke or as leachate, of a range of pollutants including heavy metal additives and dioxins.

A four-year survey of 63 landfills in Germany revealed that 13 fires occurred, requiring the attendance of the fire services. Some fires deep in the landfill may take several months to be brought under control.

Sometime fires are deliberately started at landfills, as a way of reducing waste volumes, or for recovery of scrap metals such as copper from PVC cable. Smoke from these fires contains a wide range of products of incomplete combustion, including dioxins, aromatic hydrocarbons and aldehydes.

A recent study in Germany showed that PVC is the source of virtually all dioxins formed in landfill fires. The US Environmental Protection Agency estimates that one fifth of total dioxin releases into the air in the US are the products of landfill fires.

Dioxins are among the first twelve Persistent Organic Pollutants (POPs) world governments, including all Baltic countries, have agreed to eliminate under the Stockholm Convention, signed in May 2001.

To achieve zero releases of dioxins from industry, releases of dioxins must be prevented at the source by changing the industrial processes that result in their formation. All industrial uses of chlorine and chlorinated organic chemicals lead to dioxin formation at one or more points in their lifecycle, so the phase-out of dioxin sources necessitates the phase-out of all chlorine use in industry. The use of end-of-pipe pollution control devices, filters, treatment systems and disposal methods such as burning or burying, shifts chemicals from one environmental medium to another or delays their release until a later date. The incineration of wastes that contain chlorine can also be a dioxin source in itself and should, therefore, be phased out.

If the exposure of the human population to dioxins is to be significantly decreased, it is imperative that radical measures to eliminate dioxins are implemented immediately because there is already a large burden of dioxins in the global environment that will persist for many years.

<u>Recommendations:</u>

- all governments attending the Stockholm meeting to sign the POPs treaty
- all governments to commit to eliminating all POPs, including dioxins, within one generation (25 years)
- all governments and industry nonetheless to act immediately to eliminate POPs, including dioxins. This will require an immediate end to the expansion of known or suspected POPs sources and the elimination of all known existing sources of POPs. It will also require that existing stockpiles of POPs are destroyed by means other than incineration which does not destroy POPs but causes their further formation and spreads them more widely into the environment.

6.5 Alternatives to PVC Products

For virtually all PVC applications, safer alternatives exist. It is possible to use more sustainable, traditional materials, such as paper, wood or local materials.

PVC can also be replaced by a variety of other, less environmentally damaging plastics. However, most plastics pose some risk to the environment and contribute to the global waste crisis.

Alternatives are available on the market for the vast majority of all PVC uses. Construction applications, such as pipes, fittings, sidings, and window profiles, account for over 50 percent of PVC consumption. Other PVC uses include furniture, wall and floor coverings, automobiles, electronic equipment, wire and cable coatings, packaging, and medical devices. The most appropriate substitute depends upon the qualities required for each PVC application.

<u>**Alternatives**</u>

- Window profiles - Wood
- Pipes - Concrete, steel, galvanized iron, copper, clay, chlorine-free plastics, including high-density polyethylene (PE), polypropylene (PP) and polyisobutylene.
- Flooring - Linoleum, wood, stone, rubber, PE and PP.

- Cable coatings - PE, ethylene-vinylacetate copolymer (EVA); polyamide, silicone, and other thermoplastic elastomers.
- Packaging - No packaging at all, glass, paper and cardboard, PP, PE, and polyethylene terephthalate (PET).
- Wall coverings - Paint, tiles, paper-based wallpaper.
- Roof-sheeting - Synthetic rubber, polyolefin sheeting, traditional materials made from tar, wood, and other materials.
- Gutters - Galvanised iron.
- Shutters and blinds - Wood and chlorine-free plastics.
- Furniture - Wood, metal, textiles, leather, and chlorine-free plastics such as butadiene-polyamide copolymer.
- Office supplies - Metal, wood, PP, PE.
- Automobiles - Metal, textiles, chlorine-free plastics, including polyolefins.
- Medical uses - Glass, latex, chlorine-free plastics including PP, PE, PET, EVA, polybutylene terepthalate, block copolymers, and silicones.

Abbreviations:

PVC **:** Poly Vinyl Cloride
VCM: Vinyl Chloride Monomer
CA: Chlorine Alkali
LDPE: Low Density Polyethylene
HDPE: High Density Polyethylene
EG: Ethylene Glycol
PP: Polypropylene
EVA: Ethylene Vinylacetate
PE: Polyethylene
PET: Poly Ethylene Terephthalate
ACN: Acrylonitrile
PA: Phthalic Anhydride
PTA: Pure Terephthalic Acid
EDC: Ethylene Dichloride
CFCs: Chloro Fluoro Carbons
VC: Vinyl Chloride
PCBs: Polychlorinated Biphenyls
DDT: Dichlorodiphenyltrichloroethane
POPs: Persistent Organic Pollutants
NGOs: Non-Governmental Organisation

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