Organic screen and heavy metal analysis of waste samples associated with the Petkim Petrochemical complex, Aliaga, Turkey, 1998

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Introduction

In April 1998, eleven samples of solid and liquid waste were collected from four open waste lagoons belonging to the Petkim Petrochemical complex. This dumpsite at Aliaga is situated close to the Mediterranean coastline, and therefore concerns are raises regarding migration of these wastes from the site into the marine environment.

The Convention of the Mediterranean Sea against Pollution (Barcelona Convention, 16 February 1976) was signed and ratified by all eighteen Mediterranean coastal states, and by the European Community, in June 1990. It stated that all Contracting Parties should take appropriate measures to "prevent, abate and combat pollution of the Mediterranean Sea caused by discharges from rivers, coastal establishments or outfalls, or emanating from any land-based sources within their territories (UNEP 1982).

In addition, the provisions of the Land Based Sources (LBS) Protocol (1996) and the Mediterranean Strategic Action Programme (UNEP 1997) give priority to phasing out substances that are toxic, persistent and liable to bioaccumulate. Twelve substances have been identified as priority persistent organic pollutants (POPs). These include the pesticides DDT, aldrin, dieldrin, endrin, chlordane, heptachlor, mirex, toxaphene and hexachlorobenzene; industrial chemicals, i.e. PCBs; and unwanted contaminants such as hexachlorobenzene, dioxins and furans (UNEP 1997). However many other POPs, halogenated organic compounds and heavy metals, also toxic at low concentrations, persistent and bioaccumulative, are included in the legislation.

For example, other POPs and halogenated organic compounds include chlorinated paraffins, chlorinated phenolic compounds, polybrominated biphenlys and diphenyl ethers, organohalogenated pesticides, chlorinated solvents, chlorobenzenes, polychlorinated napthalenes, PAHs, and phthalate esters. Heavy metals selected include mercury, cadmium and lead (priority), and also zinc, chromium and copper (UNEP 1997).

The aim of this study was therefore to identify organic pollutants and heavy metal contaminants in the waste samples collected, and discuss their environmental significance in light of the environmental legislation described above.

Analytical Methodology

All samples were stored and transported to the Greenpeace Research Laboratory in analytically clean glass bottles (previously rinsed with nitric acid and pentane to remove all heavy metal and organic residues). The samples were kept cold during transit, and refrigerated immediately on arrival. Heavy metals were determined quantitatively using Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES). Organic contaminants were identified using Gas Chromatography-Mass Spectrometry (GC-MS).

Organic Screen Analysis

All solvents were of High Purity Grade (PRAG or low haloform). Glassware used in extraction and cleaning up procedures was cleaned in detergent, rinsed with tap water then deionised water, dried in the oven overnight at 105^0C, and rinsed tree times with low haloform pentane.

1) Solid Samples

For each sample, approximately 30g (wet weight) was weighed and transferred to a clean 100ml glass bottle. Samples were spiked with deuterated (d8) naphthalene (an internal standard) at a concentration of 4.7mg/kg. 15ml of pentane was added, followed by 5ml of acetone. All samples were then sonicated for 2 hours.

Extracts were decanted, filtered through a pre-cleaned hydrophobic phase separator filter and collected in reagent tubes. They were then acidified to pH 2 with 10% nitric acid. Following this, a second portion of 20ml pentane was added and the extraction procedure repeated. Finally, both extracts obtained for each sample were combined and evaporated to a volume about 3ml. The concentrated extract was cleaned through Florisil column, eluted with 95:5 mixture of pentane:toluene, evaporated down to a volume 2ml under a stream of clean nitrogen, and 1-bromonaphthalene was added as a marker.

2) Aqueous Samples

Prior to the extraction, samples were spiked with deuterated (d8) naphthalene (an internal standard) at a concentration of 150ug/l. 20ml of pentane was added, and the sample agitated for 2 hours on a bottle roller to maximise contact between solvent and sample.

After separation of the phases, the solvent extract was filtered through hydrophobic phase separator filter and collected in pre-cleaned reagent tube. The aqueous sample was acidified to pH 2 with 10% nitric acid, a second portion of 20ml pentane was added and the extraction procedure repeated. The same clean up procedure, as described above, was employed.

3) Chromatographic Analysis

Samples were analysed using a Hewlett Packard (HP) 5890 Series II gas chromatograph, interfaced with a HP ChemStation data system, and linked to a HP 5972 Mass Selective Detector operated in scan mode. The identification of the compounds carried out by computer matching against a HP Wiley 275 library of 270 000 mass spectra. Results are reported as a list of those compounds reliably and tentatively identified. Match qualities of 90% or greater are assumed to give reliable identifications; tentative identification refers to qualities between 51% and 90%. Analytes yielding match qualities of 50% or less are assumed to be unidentified.

Heavy Metal Analysis

Analytical grade reagents and analytically clean glassware were used throughout sample preparation and analytical procedures.

1) Solid Samples

Samples of solid waste were dried in an oven for 48 hours, until dry weight readings became constant. They were then crushed using a pestle and mortar until homogenous and sieved through a 2mm mesh. 0.5g of sample was weighed into a 120ml Teflon microwave vessel fitted with a screw cap and pressure relief valve. To this 10ml of deionised water was added followed by 7.5ml of concentrated hydrochloric acid and 2.5ml of concentrated nitric acid. The vessels were then sealed, placed on a rotating table in a microwave oven (model MDS-2000, CEM Corp.), and allowed to digest for one hour at full power (630W).

After cooling to ambient temperature, the digests were filtered into volumetric flasks, diluted with deionised water, made up to a volume of 50ml and mixed. Certified Reference Material PACS-1 (trace elements in marine sediment, certified by the National Research Council, Canada) was prepared with the batch of samples, as was a blank sample. All were prepared in 15% v/v hydrochloric acid and 5% v/v nitric acid.

2) Aqueous Samples

Samples of liquid waste were preserved in 5% v/v nitric acid on arrival. 50ml was transferred to a 120ml Teflon microwave vessel and digested using the same procedure and programming conditions as described above. After cooling to ambient temperature, samples were filtered into volumetric flasks, diluted with deionised water, made up to a volume of 50ml and mixed. A quality control standard (internally prepared at a concentration of 8.0 mg/l) and a blank sample were prepared with every batch of twenty samples. Both were prepared in 5% v/v nitric acid.

3) ICP-AES Analysis

Following preparation all samples were analysed by ICP-AES (Inductively Coupled Plasma Atomic Emission Spectrometry) using a Varian Liberty-100 Sequential

Spectrometer. The following metals were quantified directly: manganese (Mn), chromium (Cr), zinc (Zn), copper (Cu), lead (Pb), nickel (Ni), cobalt (Co) and cadmium (Cd). A multi-element instrument calibration standard was prepared at a concentration of 10.0mg/l (matrix matched to the samples). The calibration was validated using a quality control standard, prepared from different reagent stocks, at 8.0 mg/l. Samples exceeding the calibration range were diluted appropriately, in duplicate, and re-analysed. The spectrometer was re-calibrated after twenty samples to adjust for fluctuations in sensitivity. All other instrument and laboratory quality control procedures were adhered to.

Note: Mercury analysis carried out on 4 samples (MI8007, MI8009, MI8010 and MI8015) by SouthWest Water, Exeter Laboratory, UK.

Results

See appendices 1 and 2 for full sample descriptions, results, Certified Reference Material and quality control data.

Discussion

Organic Chemicals

Large numbers of organic compounds were reliably identified in most of the waste samples. Six contained over 100 compounds (MI8009, MI8010, MI8012, MI8013, MI8014 and MI8015), with two of the waste containing over 200 compounds (MI8012 and MI8013). The majority of compounds identified were alkylated benzenes, long, straight chain hydrocarbons, polycyclic aromatic hydrocarbons (PAHs), thiophenes (organo-sulphur compounds), and biphenyl and terphenyl derivatives. All primarily derived from the distillation of petroleum or the incomplete combustion of petroleum, oil, gas and coal.

In addition, halogenated aliphatic and aromatic hydrocarbons, such as chlorinated benzenes and chlorinated solvents, were found in six of the samples (MI8009, MI8010, MI8011, MI8012, MI8013 and MI8015).

Petroleum hydrocarbons

Petroleum is a complex mixture of alkanes (straight chain hydrocarbons), monoaromatic hydrocarbons (benzenes) and polyaromatic hydrocarbons (napthalene, phenanthrene, fluorene, pyrene etc). These compounds are released into the environment through natural seeps, industrial point sources, non-point source urban runoffs, and by large quantities of accidentally released oil.

Alkylbenzenes

The occurrence of these compounds in the environment is due primarily to their presence in crude oil and petroleum products. However they are also produced following the

degradation of the linear alkylbenzene sulphonate (LAS) detergents. The alkylbenzenes are highly resistant to degradation and may accumulate in freshwater and marine sediment and soil if disposed of into these environments (Preston & Raymundo 1993). They are useful sewage markers (Chalaux et al. 1995) and due to their stability in sediments, they are very useful in tracing the transport of contaminants from their point sources. Monoaromatic and polyaromatic hydrocarbons are considered to be the most toxic, with the central nervous system (CNS) being the organ most effected following acute exposure. Impaired reaction times and impaired speech are the two most commonly noted CNS effects (Casarett and Doull 1996).

Alkylbenzenes found in these samples, which warrant concern, and for which there is an abundance of toxicological data, include benzene itself, methylbenzene (toluene), dimethylbenzene (xylene), and ethylbenzene. All are irritating to the eyes and mucous membranes, can cause irritation and burning of the skin, and all are narcotics at high concentrations. Benzene itself is a known carcinogen (4th Annual Report on Carcinogens 1985). Chronic exposure can lead to bone marrow depression, which in a few cases, can progress to leukemia (Merck 1989).

Polycyclic aromatic hydrocarbons (PAHs)

The most commonly found PAHs (and derivatives) in these samples were napthalene, fluorene, anthracene, pyrene and phenanthrene. Exposure to PAHs and PAH derivatives can deleteriously effect human health. Individuals chronically exposed to mixtures of these compounds, through inhalation or skin contact, can develop cancer (ATSDR, 1997). Many of the carcinogenic polycyclic aromatic hydrocarbons are derived from an angular benz[a]anthracene skeleton. Anthracene itself is not carcinogenic, but benz[a]anthracene appears to have weak carcinogenicity. Addition of another benzene ring in select positions, result in agents with powerful carcinogenicity such as dibenz[a,h]anthracene or benzo[a]pyrene. In addition, substitution of methyl groups on specific carbons of the ring also enhances carcinogenicity. Thus, 7,12-dimethylbenz[a]anthracene (DMBA) is one of the most powerful synthetic, polycyclic aromatic hydrocarbon carcinogens known (Williams 1986).

PAHs are proposed as a group of compounds requiring further investigation, reduction, control and monitoring under the provisions of the provisions of the Land Based Sources (LBS) Protocol (1996) and the Mediterranean Strategic Action Programme (UNEP 1997). By the year 2010, the recommendations of the Action Programme are to reduce current inputs of PAHs by 25%, with the long term objective of phasing out to the fullest possible extent, inputs of PAHs by the year 2025.

Dibenzothiophenes

These organo-sulphur, petroleum related compounds were also identified in many of the samples. Examples include dimethyldibenzothiophene, methyldibenzothiophene, and methylnaptholthiophene. Members of this group of compounds have been found to be toxic by the Microtox (R) and Daphnia magna bioassays (Seymour et al 1997).

Biphenyl and terphenyl compounds

These aromatic hydrocarbons are used specifically as fungicides (e.g. oranges, applied to the sides of shipping containers) and more generally, in organic synthesis (Merck 1989). Little is known regarding their toxicity. No data is available for terphenyl. However, CNS depression, paralysis and convulsions have been observed in animals exposed to biphenyl (Merck, 1989).

Chlorinated Solvents and Chlorobenzenes

Examples of organochlorines, used most frequently as solvents, identified in these samples include chlorobenzene (often produced unintentionally in a number of industrial processes), trichloromethane (chloroform), dichloroethane, trichloroethane, tetrachloroethane and tetrachloroethene (perchloroethene).

Chloroform and dichloroethane may both be reasonably anticipated to be carcinogenic (4th Annual Report on Carcinogens 1985). Inhalation of large doses of chloroform can also lead to increases in blood pressure, respiratory and myocardial (of the heart) depression, even death (Merck 1989). In halation of dichloroethane vapours may cause respiratory tract irritation, central nervous system damage and liver and kidney impairment (Casarett and Doull 1996). It is used as an intermediary in vinylchloride production, and residues obtained after polymerisation (notably ethylene dichloride tar) could be a source of this and similar compounds (Merck 1989).

Tetrachloroethane, tetrachloroethene, and trichloroethane are all powerful narcotics in high enough concentrations, and at lower ones they can still be irritating to the eyes and mucous membranes (Merck 1989).

Chlorooctadecane, another halogenated aliphatic hydrocarbon, was found in four of the samples. No specific toxicological data on this compound is available. However as an organo-halogen it is still prioritised for elimination under the provisions of the LBS Protocol, 1996; phase two of the Barcelona Convention, 1995; and the Mediterranean Strategic Action Programme, 1997 (UNEP 1997).

Heavy Metals

As mentioned above, in accordance with the provisions of the LBS Protocol, 1996; phase two of the Barcelona Convention, 1995; and the Mediterranean Stategic Action Programme, 1997, certain heavy metals, also toxic, persistent and liable to bioaccumulate, are included in the legislation. Hg, Cd and Pb have been selected as priority contaminants, as well as Zn, Cu and Cr (UNEP 1997).

The following heavy metals were detected in the waste samples in significant concentrations:

Mercury

Hg concentrations associated with clean sediments are extremely low, with levels ranging from 0.03 mg/kg to 0.2 mg/kg (Bryan and Langston, 1992, Salomons and Forstner, 1984; Licheng and Kezhun, 1992). Elevated Hg concentrations in aquatic systems are primarily due to anthropogenic discharges of inorganic Hg. With sediments associated with gold mining sites and chlor-alkali discharges, the two major sources of anthropogenic Hg in the environment, containing levels ranging from 0.6 to over 150 mg/kg (Bryan and Langston, 1992; Reuther, 1994; Nriagu, 1992; Maserti and Ferrara, 1991).

7.0 mg/kg was found in sample MI8009, a level approximately 35-200 times higher than background concentrations, depending on which data set is used for comparison.

Hg is a non-essential trace metal, having no biochemical or nutritional function. Biological mechanisms for its removal are poor, and Hg is the only metal known to biomagnify i.e. progressively accumulate, through the food chain (WHO, 1989; ICME, 1995). It is extremely toxic to both animals and plants at low concentrations. Therefore any elevation above baseline levels could have a deleterious effect on any exposed biota (ATSDR, 1997). Therefore environmental legislation exists in abundance to control and monitor, and often prohibit, Hg discharges (e.g. 75/437/EEC; 82/176/EEC; 84/156/EEC; 85/513/EEC; 78/319/EEC).

European Environmental Legislation Council Decision 83/101/EEC, for the protection of the Mediterranean against pollution from land-based sources, lists Hg and its compounds in Annex 1. They are considered toxic, persistent and bioaccumulative, and thus their discharge, whether directly from outfalls discharging into the sea or through coastal disposal; or indirectly, through rivers, canals, other watercourses, or though runoff, should be eliminated.

Since "Minimata", the implementation of widespread regulations on Hg disposal has greatly reduced the threat of similar incidents. However the retention of Hg by benthic sediments may delay the elimination of contamination for many years. Thus for example, concentrations as high as 100 mg/kg were still present in sediments at certain sites in Minimata Bay ten years after discharges ceased (Bryan and Langston, 1992; Tsubaki and Irukayama, 1977).

Although there is evidence which links levels of total Hg in the environment with those in higher predators such as fish, concern centers on methylmercury (MeHg) accumulation. Inorganic Hg can be methylated by micro-organisms indigenous to soils, sediments, fresh water, and salt water, the process being mediated by various microbial populations under both aerobic and anaerobic conditions (ATSDR, 1997). It widely acknowledged that organic forms of Hg are even more toxic than inorganic forms.

Bioaccumulation of methylmercury in aquatic food chains is of interest because it is generally the most important source of non-occupational human exposure to the element

(EPA 1984; ATSDR, 1997). As mentioned, Hg is a highly toxic, bioaccumulative, and persistent metal. It has no beneficial effects in humans, and there is no known homeostasis for it. Any long-term exposure may therefore be expected to progressively cause severe disruptions in the normal functioning of any accumulating organ (Nriagu, 1988). Such accumulating organs include the kidneys, liver and central nervous system. Exposure to high enough levels of metallic, inorganic or organic Hg can permanently damage these organs (ATSDR, 1997).

Lead

Uncontaminated marine and freshwater sediments will usually contain less 50 mg/kg of Pb (Salomomns and Forstner, 1984; Bryan and Langston, 1992; Palanques, 1994; Palanques et al., 1995). Elevation above this are usually due to anthropogenic discharges of Pb again result from mining and smelting operations. With less direct, yet still significant sources, arising from urban runoff, domestic sewage discharges, and automotive emissions (ATSDR, 1997).

15 g/kg of Pb was detected in sample MI8016. There are a number of possible sources of this anomalously high level of Pb. It is added, in the form of tetra-ethyllead, to petrol, as an antiknocking agent. Thus if leaded petrol is being manufactured at the petrochemicals complex, Pb bearing wastes could results. Alternatively, Pb is widely present in construction materials e.g. tank linings, piping and other equipment handling corrosive gases and liquids. It is often used as such in petroleum refining and halogenation processes for these reasons, and therefore could be present in waste residues in appreciable amounts. Thirdly, it is added as a stabiliser to PVC, to prevent the decomposition of the polymer. Without it, PVC has a tendency to degrade upon heating or on prolonged exposure to light. Excess lead could be present in any waste residues associated with this process.

Even though Pb is not considered to be one of the most environmentally mobile metals, often heavily bound to suspended particulate and sediment material (Berg et al., 1995; Hapke, 1991), there is appreciable evidence showing that sediment Pb is available to deposit-feeding species (Bryan and Langston, 1992).

Unlike some heavy metals, Pb is not required in trace amounts by animals (including humans) or plants for normal growth and development. It has no known nutritional or biochemical function and if present in sufficient quantities will inhibit animal and plant growth, development and health.

In terms of human health, the effects of Pb are the same irrespective of whether it is inhaled or ingested. Pb can cause irreversible central nervous system damage and decreased intelligence at extremely low doses. At higher levels of exposure anaemia may result, along with severe kidney damage. Children are especially susceptible to Pb poisoning because they absorb and retain more Pb in proportion to their weight than adults.

European Environmental Legislation Council Decision 83/101/EEC, for the protection of the Mediterranean against pollution from land-based sources, lists Pb in Annex 2. The Directive states that releases of Pb from land-based sources, whether directly from outfalls discharging into the sea or through coastal disposal; or indirectly, through rivers, canals, other watercourses, or though runoff, should be strictly limited, and continuously monitored.

Copper

Elevated levels of Cu were found in samples MI8008 and MI8011. With Cu present at levels approximately twenty times greater than background / normal concentrations in sample MI8012 (Salomomns and Forstner, 1984; Bryan and Langston, 1992; Palanques, 1994; Palanques et al., 1995). Although essential for living organisms at very low concentrations, Cu is still one of the most toxic metals to aquatic organisms. There is considerable experimental evidence that a large number of species are sensitive to dissolved Cu in the range 1-10 ug/l (Nelson et al., 1988; Martin et al., 1981; Giudici and Guarino, 1989).

A very significant relationship between Cu levels in aquatic biota and the levels found in sediments has been demonstrated, with clear relationships found between animal and sediment concentrations from as little as 10 mg/kg to more than 2000 mg/kg. Thus if there is any chance that wastes dumped on this coastal site is entering the sea, or contaminating groundwater supplies, this bioconcentration and resulting toxicity assumes considerable importance.

Cu in trace amounts is necessary for good health. However very large single or daily intakes of Cu, or prolonged exposure to lower levels can have adverse effects on human health. Consumption of food or drinking water containing elevated levels of Cu can result in vomiting, diarrhoea, stomach cramps and nausea (ATSDR 1997).

The most important discharges of Cu arise from mining, smelting and metal plating operations; agricultural runoff (Cu compounds are used as nutritional supplements in fertilisers and animal feed, fungicides and other agricultural chemicals) and domestic sewage effluents (ATSDR, 1997).

European Environmental Legislation Council Decision 83/101/EEC, for the protection of the Mediterranean against pollution from land based sources (Barcelona Convention), lists copper in Annex 2. Thus releases from land-based sources, whether from outfalls discharging into the sea or through coastal dumping, should be strictly limited and continuously monitored.

Zinc

Elevated levels of Zn were found in samples MI8007, MI8008, MI8011 and MI8012. In sample MI8007 824 mg/kg of Zn was determined. Based on much published data, approximately eight times greater than typical background / normal concentrations of less

than 100 mg/kg (Salomomns and Forstner, 1984; Bryan and Langston, 1992; Palanques, 1994; Palanques et al., 1995).

Although Zn is not regarded as being especially toxic, it is sometimes released into the environment in appreciable quantities, and can thus have deleterious effects on certain species at specific concentrations. For example, effects on fertilisation and embryonic development have been observed in species of fish (Ojaveer et al., 1980; Verriopoulos and Hardouvelis, 1988).

Although most of the studies relating to the human health effects of Zn concentrate on exposure via inhalation (which can cause a specific short-term disease called metal fume fever) less is known about the long term effects of ingesting too much Zn, through food, water or dietary supplements. Like Cu, it is an essential trace element, but ingestion of higher than recommended levels can have adverse effects on health. The Recommended Dietary Allowances for Zn are 15 mg/day for men and 12 mg/kg for women. If doses 10 –15 times higher than these recommendations are taken by mouth, even for a short time, stomach cramps, nausea and vomiting may occur (ATSDR, 1997). Ingesting high levels for several months may cause anaemia, damage to the pancreas, and decreased levels of high-density lipoprotein (HDL) cholesterol (ATSDR, 1997).

European Environmental Legislation Council Decision 83/101/EEC, for the protection of the Mediterranean against pollution from land based sources (Barcelona Convention), lists Zn in Annex 2. Whilst not considered as toxic, persistent and bioaccumulative as the metals listed in Annex 1 (Cd and Hg), it does exhibit similar characteristics. Therefore the Directive does state that releases of Zn from land-based sources, whether from outfalls discharging into the sea or through coastal dumping, should be strictly limited and continuously monitored.

Nickel

17 g/kg of Ni was found in sample MI8017 (labelled Homo Atactic polypropylene). Many Ni compounds are used as catalysts in organic synthesis, notably hydrogen addition of oils and other organic compounds (e.g. Raney Nickel). Therefore it is quite feasible that it is being used in this way at the Petkim plant, and the waste catalyst dumped on the coastal site.

Ni is considered an essential trace element at very low concentrations. It does bioaccumulate in aquatic systems, and as such elevations above normal concentrations can result in deleterious aquatic effects (ATSDR 1997).

The most common adverse health effect of Ni in humans is an allergic reaction. People can become sensitive to Ni when jewelry or other things containing Ni are in direct contact with the skin. Once a person is sensitized to Ni, further contact with the metal will produce a reaction. The most common reaction is a skin rash at the site of contact. In some sensitized people dermatitis may develop at a site away from the site of contact. For example, hand eczema is fairly common among sensitised people. Less frequently, some

people who are sensitive have asthma attacks following exposure. People who are sensitive to Ni have reactions when nickel is in contact with the skin, and some sensitized individuals react when they eat nickel in food or water, or breath dust containing Ni.

European Environmental Legislation Council Decision 83/101/EEC, for the protection of the Mediterranean against pollution from land-based sources, lists Ni in Annex 2. The Directive states that releases of nickel from land-based sources, whether directly from outfalls discharging into the sea or through coastal disposal; or indirectly, through rivers, canals, other watercourses, or though runoff, should be strictly limited, and continuously monitored.

Manganese

11 mg/l of manganese was found in sample MI8014. Manganese chloride can be used as a catalyst in the chlorination of organic compounds, and this would explain why it is present in such high levels in this sample of waste.

European Environmental Legislation Council Decision 83/101/EEC, for the protection of the Mediterranean against pollution from land based sources (Barcelona Convention), lists Mn in Annex 2. Thus releases from land-based sources, whether from outfalls discharging into the sea or through coastal dumping, should be strictly limited and continuously monitored.

Conclusion

From even this limited study, it is evident that highly complex wastes are being disposed of on this coastal site. Large numbers of compounds were detected, for which toxicological information exists for only a few. Therefore it becomes difficult to correctly assess the environmental risk migration of these waste products will have on exposed human populations and the marine environment.

In order to implement the provisions of the LBS Protocol (1996) / Barcelona Convention (phase two, 1995) / 1997 Mediterranean Strategic Action Programme, far greater control on waste dumping is required. The disposing of potentially hazardous wastes must cease, and long term and sustainable solutions to increased levels of hazardous waste generation, must concentrate on the development of cleaner technologies and not merely on end of pipe solutions.

As is the case for all the Mediterranean countries, Turkey must comply with all environmental legislation regarding land based anthropogenic inputs of pollution to the Mediterranean Region. If not, further decay of inland, inshore and nearshore waters will be a certainty. The time to address the problems of waste production and disposal, and to prevent widespread environmental decay, is here, and governmental departments and industrialists alike must acknowledge this and act immediately.

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