OSPAR COMMISSION

Background Document on Polycyclic Aromatic Hydrocarbons (PAHs)

Hazardous Substances Series

2009

OSPAR Convention

The Convention for the Protection of the Marine Environment of the North-East Atlantic (the “OSPAR Convention”) was opened for signature at the Ministerial Meeting of the former Oslo and Paris Commissions in Paris on 22 September 1992. The Convention entered into force on 25 March 1998. It has been ratified by Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Luxembourg, Netherlands, Norway, Portugal, Sweden, Switzerland and the United Kingdom and approved by the European Community and Spain.

Convention OSPAR

La Convention pour la protection du milieu marin de l'Atlantique du Nord-Est, dite Convention OSPAR, a été ouverte à la signature à la réunion ministérielle des anciennes Commissions d'Oslo et de Paris, à Paris le 22 septembre 1992. La Convention est entrée en vigueur le 25 mars 1998. La Convention a été ratifiée par l'Allemagne, la Belgique, le Danemark, la Finlande, la France, l’Irlande, l’Islande, le Luxembourg, la Norvège, les Pays-Bas, le Portugal, le Royaume-Uni de Grande Bretagne et d’Irlande du Nord, la Suède et la Suisse et approuvée par la Communauté européenne et l’Espagne.

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This report has been prepared by Ms Elizabeth Fadum for Norway as lead country.

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Contents

Executive Summary

Polycyclic aromatic hydrocarbons (PAHs) are a group of organic chemicals consisting of molecules with 2 or more fused benzene rings and naphthalenes. They are toxic and bioaccumulate especially in invertebrates. Although vertebrates metabolise them, PAHs are reactive compounds, and some are carcinogenic. OSPAR identified them in 1994 as requiring priority action, and they were therefore included in the 1998 OSPAR List of Chemicals for Priority Action.

PAHs are emitted from a wide variety of sources. The sources of greatest significance vary between countries, but the majority of PAHs are released by incomplete combustion of fossil fuels and wood. Sources in industry are the manufacture of aluminium and coke ovens. Emissions may also occur via evaporation or leaching from PAH containing materials. Point sources have been regulated, but total elimination of PAH releases is almost impossible. Restriction on the use of creosote treated wood has reduced the importance of this source for diffuse releases of PAHs. The Söderberg technique in the primary aluminium industry was a major source in at least some areas The latest implementation reporting in the aluminium sector in 2008 showed that of the 19 aluminium plants still operating in the OSPAR Convention area only 3 were still using Søderberg technology.

PAH concentrations in seawater vary widely, from 0,001 ng/l to 0,3 ng/l, but can reach 8 500 ng/l in estuaries and coastal areas. Sediment concentrations in estuaries can vary from 0,2 to more than 6 mg/kg (dry weight).

Existing OSPAR measures on PAHs concentrate are in the aluminium industry and coatings of ships' hulls. The EC Directives on integrated pollution prevention and control, on the incineration and land-filling of waste and on restrictions on the marketing and use of certain dangerous substances and preparations are also relevant. Controls are under development or discussion on domestic combustion units (CEN, EU), creosote and road-vehicle fuels (EC). Norwegian effect monitoring shows that discharges of PAHs from the offshore industry cause little biological impact.

There are still substantial releases to air and water. Data on discharges, emissions and losses of PAH is not of sufficient quality for various reasons. An overall trend in releases is not possible to give. However, for some sources, reductions have been achieved due to technical improvements *e.g.* in the aluminium production. There is indication that in some sectors and for some Contracting Parties emissions to air might be stagnant or even increasing.

It is expected that new and stricter emission limits for cars and trucks in the EU will reduce the PAH emission from this diffuse source. The full and effective implementation of the Water Framework Directive for PAHs will also support further reduction in releases. However, additional efforts are needed to address especially emissions to air from combustion processes, but it will not be possible to eliminate all emissions. It is therefore doubtful that cessation of PAH releases can be achieved.

Récapitulatif

Les hydrocarbures polycycliques aromatiques (HAP) sont un groupe de produits chimiques organiques composés de molécules à 2 anneaux de benzène combinés ou à plus de 3 anneaux et de naphtalènes. Ils sont toxiques et s'accumulent biologiquement surtout chez les invertébrés. Bien que les vertébrés les métabolisent, les HAP sont des composés réactifs et certains sont cancérigènes. En 1994, OSPAR a décidé qu'ils devaient faire l'objet de mesures prioritaires, d'où le fait qu'ils aient été inscrits sur la Liste OSPAR 1998 de produits chimiques devant faire l'objet de mesures prioritaires.

Les émissions de HAP proviennent d'une grande variété de sources. Les sources les plus significatives varient d'un pays à l'autre mais la majorité des HAP sont rejetés par la combustion incomplète des combustibles fossiles et du bois. Les sources provenant de l'industrie sont la fabrication de l'aluminium et les fours à coke. Des émissions peuvent également se produire par évaporation ou par lixiviation à partir de matériaux contenant des HAP. Les sources ponctuelles ont été réglementées mais l'élimination totale des rejets de HAP est pratiquement impossible. La restriction de l'utilisation de bois traité à la créosote limite l'importance de cette source de rejets diffus de HAP. La technique Söderberg dans l'industrie primaire de l'aluminium représentait une source majeure, tout au moins dans certaines zones. La toute dernière notification de la mise en œuvre pour le secteur de l'aluminium, en 2008, révèle que 19 usines d'aluminium fonctionnent encore dans la zone de la Convention OSPAR, trois seulement utilisant la technologie Søderberg.

Les teneurs en HAP dans l'eau de mer varient dans de fortes proportions, puisqu'elles vont de 0,001 ng/l à 0,3 ng/l, tout en pouvant atteindre 8 500 ng/l dans les estuaires et les zones côtières. Dans les sédiments des estuaires, les teneurs peuvent fluctuer entre 0,2 à plus de 6 mg/kg (poids à sec).

Les mesures OSPAR qui visent actuellement les HAP sont centrées sur l'industrie de l'aluminium et sur les revêtements des coques des navires. Les Directives communautaires européennes relatives à la prévention de et à la lutte intégrées contre la pollution, à l'incinération et à la mise en décharge des déchets, aux restrictions de commercialisation et d'utilisation de certaines substances dangereuses et aux préparations sont aussi pertinentes. Des règlements visant les appareils ménagers de combustion (CEN, CE), la créosote et les combustibles pour véhicules routiers sont en cours d'élaboration ou sont discutés (CE). La surveillance norvégienne des effets révèle que les rejets de HAP par l'industrie de l'offshore ont un impact biologique faible.

Les mesures OSPAR existantes sur les teneurs en HAP portent sur l'industrie de l'aluminium et le revêtement des coques de navires. Les Directives de la CE sur la prévention et le contrôle intégrés de la pollution, sur l'incinération et la mise en décharge des déchets et sur la limitation de la mise sur le marché et l'emploi de certaines substances et préparations dangereuses sont également pertinentes. Des contrôles sont en cours de développement ou font l'objet de discussions. Ils portent sur les appareils ménagers de combustion (CEN, UE), la créosote et le carburant pour véhicules routiers (CE). La surveillance norvégienne des effets révèle que les rejets de HAP par l'industrie de l'offshore ont un impact biologique faible.

Des rejets substantiels dans l'atmosphère et l'eau subsistent. La qualité des données sur les rejets, émissions et pertes de HAP n'est pas suffisante pour diverses raisons. Il est impossible d'indiquer une tendance générale des rejets. Dans le cas de certaines sources des réductions ont cependant été réalisées grâce à des améliorations techniques, dans le domaine de la production de l'aluminium par exemple. Il semblerait que dans certains secteurs et pour certaines Parties contractantes les émissions atmosphériques soient inchangées ou même en hausse.

1. Basis and rationale for action

1.1 Basis

The objective stated in the OSPAR Strategy with regard to Hazardous Substances, which was adopted in Sintra in 1998 and endorsed by Ministers is

> "*to prevent pollution of the maritime area by continuously reducing discharges, emissions and losses of hazardous substances, with the ultimate aim of achieving concentrations in the marine environment near background values for naturally occurring substances and close to zero for man-made synthetic substances*".

The basis for OSPAR's work for achieving this objective is also set out in the Strategy, which also includes a timeframe, which states that every endeavour will be made

> "*to move towards the target of the cessation of discharges, emissions and losses of hazardous substances by the year 2020*".

PAHs are on the OSPAR List of Chemicals for Priority Action set out in Annex 2 of the Strategy with regard to Hazardous Substances for which a background document should be drawn up (see OSPAR Action Plan 1998-2003).

This background document addresses this obligation, and has the aim of identifying the main sources of PAHs, and its various pathways into the marine environment.

1.2 Background

In 1994 the Oslo and Paris Commissions decided, as a priority issue, to include PAHs in their Action Plan. According to the Plan all sources of anthropogenic PAH of concern should be considered and measures should be developed to make significant reductions of inputs to the marine environment. To this end, work has already been carried out in OSPAR's Working Group on Diffuse Sources in the period up to 1997.

In order to work out an inventory of all relevant sources as a basis for decisions to be taken on measures for PAHs, a questionnaire to gather information about national sources of PAH emissions (diffuse and point sources) was sent from Norway to the Contracting Parties in March 1994.

The results from the questionnaire returns were presented in 1994. Seven Contracting Parties had responded, but the responses were heterogeneous and did not cover all sources listed in the questionnaires. On this basis it was difficult to compare the figures and evaluate the relative importance of the different sources.

In 1995 several Contracting Parties stated that the reason why they had submitted no data or only a limited amount of data was that national statistics concerning factors for emissions of PAHs from diffuse sources were lacking.

In 1996 Norway presented a guidance document concerning the estimate of emissions of PAHs from diffuse sources. Norway received response from only one country presenting data based on emission factors as recommended in the guidance document. However, the guidance document did not, as intended, result in any new data from countries that had earlier sent insufficient data.

The inventory (see Annex 1) covers information about emissions of PAHs in nine countries. It is likely that all main sources are identified on the basis of the reported figures. However, lack of quantitative data on various sources still makes it difficult to assess the relative importance of the sources in each of the countries.

The report “The European Inventory of Heavy Metals and Persistent Organic Pollutant for 1990” (7) provides data for emission of PAHs to air in inter alia OSPAR countries. This report by the Netherlands organisation for applied scientific research (TNO) was a preparatory step towards the preparation of the European

CORINAIR95 emission inventory. In cases where reported data were lacking, PAH emissions have been estimated by TNO. Estimated emissions are still regarded as useful information in the case of identifying the most important sources of emissions of PAHs to air.

The TNO report mentioned above provides emission data of PAHs from 1990. Keeping in mind the difficulties of collecting national PAH emission data, no effort has been made to update these figures. One should expect that enhanced environmental awareness in the European countries during the last 10 years has led to reduced emissions of PAHs. On the other hand, increased living standards have resulted in increased consumption (energy, traffic, etc.) which may result in increased emissions of pollutants.

In 1997 it was agreed that Norway as lead country should draft a proposal on Best Environmental Practice (BEP) for the prevention or reduction of releases of PAH from the use of creosote treated timber, and also Best Environmental Practice (BEP) for reduction of emissions of PAH from domestic solid fuel combustion appliances.

This background document deals with PAHs as a group of pollutants emitted from various types of processes etc. and not with individual PAH compounds as products (*e.g.* anthracene).

2. Identification of sources of PAHs and relevant pathways to the marine environment

2.1 PAHs

The polycyclic aromatic hydrocarbons (PAHs) are a group of compounds consisting of molecules containing 2 or more fused benzene rings, although bicyclic compounds sometimes are included in the term (*e.g.* USEPA 16 PAHs). PAH compounds are toxic, and they bioconcentrate especially in invertebrates (organisms without spinal column) in the aquatic environment. Vertebrates (fish, birds, mammals) metabolise PAHs, however the PAH metabolites are reactive compounds and some of those are carcinogenic. The bioconcentration in plants seems to be low. The PAH compounds also photochemically degrade, and in air reactions with *e.g.* nitrogen oxides forming nitro-PAHs have been detected.

Some institutions, such as the US EPA, include the bicyclic compound naphthalene in the PAH-parameter, others do not (see Annex 2). Naphthalene is classified according to Council Directive 67/548/EEC as very toxic to the aquatic environment and may cause long term effects. In the framework of Directive 2000/60/EC of the European Parliament and of the Council (Water Framework Directive) has in June 2001 agreed on a list of priority substances (Annex X of WFD), including substances identified as priority hazardous substances. The list as amended by Directive 2008/105/EC identifies polyaromatic hydrocarbons as well as anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(ghi)perylene, benzo(k)fluoranthene and indeno-(1,2,3-cd)pyrene, as priority hazardous substances, and naphthalene as priority substance.

International standards to measure PAH have not yet been established. Consequently various amounts of PAH compounds have been monitored depending on the measuring methods, national traditions, international agreement, etc. (see Annex 2). Therefore comparison of PAH measurement results containing different amounts of PAH compounds must be done carefully.

2.2 Sources of PAHs

An indicative overview of sources and sub-sources of PAHs in 2001 is shown in Table 1.

Table 1: *Indicative overview of sources and sub-sources of PAH (cf. HARP-HAZ Prototype (18))*

NOSE Codes[1]	Sources	Discharges to water	Emissions to air
	Agricultural Activities		
110.03	On field burning of stubble/straw	X	XX
	Transport and infra structure		
201	Road transport	XX	XX
202.03	Inland waterways	X	X
202.04	Maritime Activities	X	X
202.05	Air traffic		XX
	Building materials		
105.16	Construction and demolition (use of creosote treated timber)	XX	X
	Households		
101.07	Other equipments (domestic combustion of wood, oil, coal and peat)	X	XX
	Small and medium industrial activities (SME)		
	Industrial activities (IPPC)		
101	Combustion processes (Power generation)	X	XX
104.07/ 105.07	Manufacture of pulp, paper and paper products, publishing and printing (combustion of wood)		XX
104.09/ 105.09	Manufacture of chemicals, chemical products and man-made fibres		XX
104.12	Manufacture of basic metals and metal products (Carbide production)	(X)	XX
105.01.21/ 107.04.06	Wood preservation without solvents/ Preservation of wood with solvents (creosote and carbolineum treated timber)	X	XX
105.12.01	Coke oven furnaces (door leakage and extinction)	X	X
105.12.03	Pig iron tapping	(X)	(X)
105.12.08	Smelters of Iron and Steel	X	XX
105.12.11	Rolling mills	(X)	(X)
105.12.21/ 15.12.22	Aluminium production	XX	XX
105.12.41/ 105.12.42	Ferro alloy Industry	X	XX
105.12.91	Building and repairing of ships	X	X
105.13.05	Anode production	X	XX

[1] The NOSE codes refers to EUROSTAT 'Proposal for NOSE amendments', January 1999.

106	Extraction and distribution of fossil fuels and geothermal energy (prod. water and cutting)	XX[2]	(X)
	Waste disposal		
109.02	Waste water treatment	X	XX
109.03	Waste incineration and pyrolysis (incl. cable burning)	X	XX
109.04	Open burning of Agricultural wastes (except stubble burning	(X)	(X)
109.05	Cremation		(X)
109.06	Solid waste disposal on land (Land fill activities)	(X)	
	Contaminated land/sediments		
	Sediments in lakes and rivers	(X)	
	Contaminated sites and soils	(X)	

XX major, X medium, (X) minor - Importance is indicated based on 'Background document concerning the identification of anthropogenic sources of PAH emissions as a basis for making decisions on measures'. Norwegian Pollution Control Authorities, 1997.

The two main contributors to PAHs in the environment are fossil fuels, mainly crude oil, and incomplete combustion of organic material.

From combustion processes PAHs are emitted to the air (depending on the temperature as volatile components or adsorbed on particles) when no abatement systems are in place. In general, all thermal processes containing carbon and hydrogen are potential sources of PAHs. PAH pollutants are emitted from power plants, thermal industrial processes, combustion plants, waste incinerators, wood stoves, vehicle engines, etc. as well as from natural sources, (forest fires, volcanoes). Normally the formation of PAHs from thermal processes is closely correlated to the process conditions, and the quantity of PAHs emitted depends on the efficiency of the abatement system in place.

Discharges of PAHs to water occur from onshore and offshore industrial activities, and from dumping of dredged material mainly.

PAHs are the biocide component in tar, creosote and similar products used for material preservation and protection purposes. PAH compounds are also components in asphalt. Emission to air and spillage to soil from wood preserving industry, asphalt works, etc., as well as emission and leakage from treated wood and tarred materials and constructions contribute to the total emission of PAHs.

Uncontrolled deposits of PAHs-containing waste (industrial waste, treated wood, etc,) are potential sources of PAHs, with particular risk of polluting the waterbodies. The leakage of PAHs from deposits can be significant when the deposits are located on the shore.

Information about the major emission point sources of PAHs in OSPAR Contracting Parties was collected in 2001 by Norway from the Contracting Parties. The reported, most significant, sources are listed in Tables 2 and 3 (Ref. 1 - 5, 7, 8).

[2] The major part is naphthalene.

Table 2: *Point sources of emissions to air and discharges to water of PAHs in the OSPAR countries, (2001, Ref. 1 - 5, 7, 8).*

Point source	**Countries reporting significant emissions**
Power generation	The Netherlands, Belgium, UK, Denmark, Switzerland
Primary aluminium industry	The Netherlands, UK, Norway, Sweden, Switzerland
Anode production	Norway
Iron and steel industry	The Netherlands, Belgium, Sweden, Switzerland
Ferroalloy industry	Norway
Carbide production	Norway
Asphalt works	Belgium, Norway
Prod. of creosote treated timber	The Netherlands, Belgium, Finland
Prod. of carbolineum treated timber	Belgium
Shipyards	The Netherlands, Belgium
Coke ovens	Germany, Belgium, Sweden
Chemical industries	The Netherlands
Pulp and paper industry (combustion of wood)	Norway
Offshore industry (produced water)	Denmark, Norway, UK
Municipal waste incineration	Belgium, Norway, Denmark

Table 3: *Diffuse sources of significant emissions to air and discharges to water of PAHs in the OSPAR countries (2001, Ref. 1 - 5, 7, 8).*

Diffuse source	**Countries reporting significant emissions**
Wood burning installations	The Netherlands, Belgium, UK, Norway, Sweden, Finland, Switzerland
Domestic coal combustion	Germany, UK
Domestic oil combustion	Germany, Norway, Finland, Switzerland
Ship coatings	The Netherlands
Use of creosote treated timber	The Netherlands, Switzerland
Road traffic	The Netherlands, Germany, Belgium, UK, Norway, Denmark, Finland, Switzerland, Sweden
Road construction (dust)	Belgium, Norway, Switzerland
Domestic heating (oil/coal/ gas)	Belgium
Industrial heating including wood	Belgium
Stubble burning	UK, Norway
Air traffic	Denmark

Based on the information given by the Contracting Parties circumstances regarding the major sources of emissions of PAHs are as follows:

- Primary aluminium industry: The emissions and discharges of PAHs are mainly a problem related to the Søderberg technology. Industries using the alternative prebaked-technology will mainly have emissions of PAHs from the anode baking process. Latest implementation reporting on OSPAR measures in the aluminium sector in 2008 showed that following closure of facilities and improvement of technology, of the 19 aluminium plants still operating in the OSPAR Convention only 3 were still using Søderberg technology, the most problematic technique in terms of releases of PAHs. The majority of plants (16) used combined Søderberg and prebake techniques (OSPAR 2008). ;

- Iron and steel industry: In the iron and steel industry emissions of PAHs mainly arise from the thermal processes using coal and coke, *i.e.* the sinter plants, the coke plants and the furnaces. The PAHs are formed when the combustion processes are incomplete, for example, from sinter plants significant amounts of PAHs have been measured. (approximately 100 - 800 mg PAH (EPA's 16 compounds) per tonne sinter). In the various PARCOM Recommendations on the limitation of pollution from iron and steel production installations, however, attention has not been focused on emissions of PAHs;
- Power generation: Fossil fuel power plants emit PAHs. However the emissions of PAHs from large power plants per amount of energy produced are much smaller than from small coal, coke or wood stoves because better combustion conditions and abatement techniques are in place;
- Domestic combustion: It is well documented that combustion of solid fuel, especially wood and other types of biomass, in small stoves, boilers and medium sized combustion plants, has relatively high emissions of PAHs due to poor combustion conditions in older or out of date installations. This may also create local air pollution problems in densely populated areas, especially in the cold season;
- Traffic: Road traffic, as well as other type of traffic with vehicle engines using fossil fuel, represents a diffuse source of emissions of PAHs. The amount of PAHs emitted from vehicles depends on the engine type, the age of the car/engine, the driving habits due to topography and road quality, outdoor temperature, etc. Regarding road traffic, especially in areas where studded tyres are used, road dust is an additional source of PAHs;
- Creosote treated timber: In temperate and warm climates, the emissions of PAHs from creosote and tar treated timber, can be significant. Leakage of PAHs from spillage at wood preservation plants and from treated timber and material also represent sources with runoff potential to waterbodies. Leakage from treated timber or construction which are in direct contact with water can be significant;
- Ship coating, ship yards: The use of ship coating, of which one of the components is based on preparations from coal tar pitch or coal tar distillates, has been identified as a source of PAHs in certain areas of the marine environment. By 2006, Contracting Parties reported that the use of one-component coal tar systems is phased out. There are still 12% of inland ships in the Netherlands using such systems which have been obtained abroad and the UK is making additional efforts to speed up the replacement of one-component systems (OSPAR 2006). The measure does not apply in Belgium;
- Dredged material: According to a rough estimate the order of magnitude of wet dredged material dumped in the North Sea in 1995 was 200 – 250 Mtonnes (15). When dredging contaminated sediments, the pollutants in the sediments will be mobilised, and the pollutants in dredged material will contribute to the total load of pollutants in the effluent discharged during dredging. According to data reported by Germany, the Netherlands, Norway and Spain in OSPAR Reports on Dumping of Wastes at Sea, 22,3 tonnes of PAHs in dredged material were dumped in 1995 and 48,7 tonnes in 1996;
- Offshore: Produced water from offshore installations contains PAHs and naphthalenes. The discharges from the Danish sector have been estimated to approximately 2 tonnes per year (US EPA's 16 PAHs). The discharges of PAHs (US EPA's 16 PAHs) from offshore activities in Norway were approximately 26 tonnes in 1998, however, the discharges of naphthalene comprised approximately 24 tonnes of these discharges. In 2007 the Norwegian discharges of PAH (EPA's 16 PAHs) was approx. 53 tonnes. The reported emissions of PAHs (EPA's 16 PAHs) to air in the Norwegian sector in 1998 were very low (approx. 0,03 kg) and approx. 0,04 tonnes in 2007. In 1998, the UK reported discharges of approximately 64 tonnes of PAHs (including naphthalene) to sea.

- Ship traffic: There are emissions of PAHs to air and discharges of PAHs to water from ship traffic, however no information about the pollution load has been found.
- Oil spill: There are discharges of PAHs to water from oil spill, however no information about the pollution load has been found.

In addition to the major diffuse sources of PAHs mentioned above, considerable emissions of PAHs have been reported from road construction. PAHs are also emitted from all kinds of open-air fires such as straw and stubble burning. However, a quantification of such emissions is difficult.

2.3 Pathways to the marine environment

PAHs are spread to the marine environment by both atmospheric and aquatic pathways.

When PAHs are emitted to ambient air, some of the PAH compounds are in a gaseous phase, others adsorbed on particles, and the semi-volatile PAH compounds are partly gaseous, partly particle adsorbed, depending on the temperature and the present particle concentration. Normally in stack gas from combustion appliances, the PAH compounds containing 2 - 3 benzene rings are gaseous, while those containing more benzene rings are either semi-volatile or totally adsorbed on the dust or soot particles. Airborne PAHs will be transferred to soil and water surfaces by dry deposition and by particle fallout. Depending on the temperature, re-emission from soil can occur. The mobility of PAHs in the soil follows the water transport.

In water the PAH compounds have a low solubility and adsorb strongly on particles, although the compounds of low molecular weight (compounds with 3 or fewer rings in the molecule) are more soluble than of those of high molecular weight (compounds with 4 or more rings). The compounds of lower molecular weight also adsorb less strongly on particles than those of high molecule weight. The mobility of PAHs in water streams is therefore highly dependent on transport of particles. And as a result of sedimentation of particles PAHs end up in sediments, finally in the marine sediments.

The PAH compounds are photochemically and biologically degradable. The half-lives of the various components vary considerably, from weeks to years, depending on the media and surrounding circumstances. Particulate bound PAHs are less available for degradation than volatile or water- soluble PAHs. Because of the lower degradation rate, lower volatility and stronger adsorbance on particles, the PAH compounds of higher molecular weight tend to accumulate in the sediments.

The lipofilic (fat soluble) nature of PAH compounds render them available for uptake and accumulation by aquatic organisms. Some of the PAH compounds are carcinogenic (see Annex 2).

3. Quantification of sources of PAHs, and monitoring data on PAHs

3.1 Quantification of sources

Based on the information reported by the OSPAR Contracting Parties and using emission factors when reported data were lacking, TNO has estimated the total amount of PAHs emitted into air from various sources in the 15 OSPAR member countries in 1990 (Ref. 9). These figures are presented below in table 4. The PAH figures are expressed as the sum of the 6 "Borneff" PAH compounds (see Annex 2).

Table 4: *The total air emission of PAHs (6 Borneff compounds; tonnes per year) in the 15 OSPAR countries (1990; ref. 9).*

Source/branch	PAH (t/a) *	Amount of total PAH load (%)
Total load	**7780**	**-**
Stationary combustion - *total*	**4310**	**55**
Public power, cogeneration and district heating	14,6	0,2
Commercial institutional and residential combustion	4220	54
• Brown coal	255	3
• Hard coal	268	3
• Fuel oils	6,80	0,1
• Other fuels	3660	47
Industrial combustion	78	1
Production processes	637	8
• Iron and steel	131	2
• Al industry	378	5
• Road paving with asphalt	112	1
Solvent use - *total*	**1820**	**23**
• Wood preservation	1640	21
Road transport	**955**	**12**
Waste incineration	5,69	0,1

* uncertainty range in estimates of atmospheric emissions of PAH stated by TNO is 2 –5

According to the data in Tables 1, 2 and 3, a few major sources of diffuse emission of PAHs dominate. These are wood preservation (found to be one the major sources in 12 OSPAR countries), stationary combustion (a large source of PAHs in 10 countries) and road transport/road traffic (considered a major source in 6 countries).Calculations done by EMEP on air emission of benzo(a)pyrene (PAH indicator) in the OSPAR member countries indicate that the PAH emission in the period 1990 - 2006 has been reduced with in the order of 50 %.

The inventory mentioned above does not include discharges or losses of PAHs to waterbodies. The information gathered by Norway in 2000 - 2001 indicates that major water related sources are ship coating, road traffic runoff and aluminium plants using Søderberg technology. The discharges from offshore installations to sea are relatively large (see Chapter 2) when naphthalene is taken into account.

Data on emissions and discharges of PAHs from various sources presented by the OSPAR Contracting Parties are given in Annex 1.

3.2 Monitoring data

The concentration of PAHs in seawater varies a lot, from 0,001 ng/l for the less water soluble PAHs (PAH components of high molecular weight) to 0,3 ng/l for the more water soluble PAHs (PAH compounds of lower molecular weight). In coastal areas and in estuaries higher concentrations have been detected, *i.e.* concentrations ranging from not detectable up to 8500 ng/l (11). Water column monitoring in the Ekofisk Region in 1999 showed concentration of 0,95 ng/l - 12,8 ng/l (EPA's 16 PAHs) (16). Water column monitoring around Norwegian offshore installations in 2006 showed that discharges of produced water do not cause significant harm to the pelagic community, the bodyburden levels of PAH in caged mussels was close to background levels. Norwegian water column monitoring was also carried out at the Ekofisk field in

2008. Results showed that accumulated PAHs-metabolites in bile of caged cod were moderately elevated suggesting low exposure values (21).

In sea sediments the concentrations of PAHs have been measured in estuaries and the results shows that they vary between 0,2 mg/kg (dry weight) to more than 6 mg/kg (dry weight). In North Sea sediments the concentrations of the most carcinogenic PAH compound, benzo(a)pyrene, have been detected in the range of 0,0006 - 0,24 mg/kg (11). Monitoring on the Norwegian continental shelf in 1996-98 showed that the concentrations of the total amount of hydrocarbons are 1,1 – 13,6 mg/kg (dry weight) (17).

In harbour sediments the concentrations of PAHs are higher due to spill from ship traffic, drains and various types of effluent. 0,7 – 36 mg /kg (dry material) has been measured in Norwegian harbour sediment (14).

3.3 Relevant OSPAR monitoring projects

PAHs have been included in the following monitoring projects initiated by OSPAR:

- Pilot study of input of selected contaminants of PAHs in precipitation and air within the Comprehensive Atmospheric Monitoring Programme (CAMP);
- Monitoring in the maritime area, in biota and sediments, to investigate temporal trends and spatial surveys in the Co-ordination of Environmental Monitoring Programmes (CEMP) as a part of monitoring within the Joint Assessment Monitoring Programme (JAMP);
- Pilot study of input of PAHs into the maritime area via rivers within the programme of Riverine Inputs and Direct Discharges (RID);
- A Quality Status Report (QSR), mapping of the regions of the maritime area, published in 2000;
- Guidelines for monitoring methods to be used in the vicinity of platforms in the North Sea (PARCOM 1988);
- Final Report on the Pilot Study and Intercomparison Exercise on Atmospheric Inputs of PAHs (INPUT);
- OSPAR Guidelines for monitoring the environmental impact of offshore oil and gas activities (2001).

3.4 Emissions to air, atmospheric deposition discharges/losses and waterborne inputs

Under the UN-ECE POP Protocol, PAHs should be reported as sum of the following four indicator compounds: benzo[a]pyrene, benzo[b]fluoranthene, benzo[k]fluaranthene, and indeno[1,2,3-cd]pyrene. It is not clear whether this has been consistently followed by Contracting Parties in reporting their emissions to EMEP. The officially reported data suggest additional uncertainties due to missing emission data from some countries, considerable fluctuations for some time series, and indication that not all sector emissions have been fully and correctly divided up by Contracting Parties for the sub-sectors. The officially reported data need therefore to be interpreted with caution and can not be used for making comparisons between countries. Against this background, the data suggest total air emissions of PAHs of 1.08 kilo tonnes for 2005 with commercial, residential and other stationary combustion (22%), industrial processes (17%) and transport (below 1000 m) (11%) as the main contributors. While the uncertainties in data do not allow a trend analysis, there is still indication that emissions show a diffuse picture and no clear trend and that emissions might have stagnated or even increased for some Contracting Parties and sectors in the 1998 - 2005. Annex 1, table 5 shows emission data of PAH and table 6 shows emissions of benzo(a)pyrene for the Contracting Parties for the period 2000-2006, as reported to EMEP.

Atmospheric deposition of PAHs from combustion processes is an important pathway to the North-East Atlantic. Hardly any data on concentrations of PAHs in precipitation have been reported by Contracting Parties as voluntary component of the CAMP and a quantification or trend statement cannot be made. A study in 2005 of the available PAH data for 1996 – 2002 showed that concentrations of PAHs in precipitation

are characterized by strong variations over the years caused mainly by the variation of meteorological conditions (OSPAR 2005a).

The total discharges of PAHs reported by Contracting Parties to EPER under their commitments under the IPPC Directive in 2001 and 2004 are 26.6 and 13.2 metric tonnes respectively. The reported discharges relate mainly to the metal and the textile industries. While uncertainties in the exact discharge figures for 2001 and 2004 exist due to inconsistencies in reporting and do not allow conclusions on trends, the discharge data still give an indication that discharges from heavily regulated point sources continue.

Riverine inputs of PAHs is an important pathway but hardly any data have been reported by Contracting Parties as voluntary parameter under the RID Study and a quantification and trend statement cannot be made.

Data reported by Contracting Parties on the load of PAHs[3] from dumped dredged sediments is incomplete. The reported loads of 29 tonnes, 172 tonnes and 192 tonnes of PAHs for dumped sediments in 2003 – 2005 therefore can only give a very rough indication of magnitudes.

In the offshore industry PAHs are discharged with produced water, which is water extracted from the subsurface with oil and gas. Produced water may include water from the reservoir and water that has been injected into the formation. The water contains various concentrations of the components of the crude oil, including PAHs and any chemicals added during the production/treatment process. In 1998, approximately 26 tonnes of PAHs were discharged with produced water from offshore activities in Norway, of which 24 tonnes were naphthalene. The UK reported for 1998 discharges of approximately 64 tonnes of PAHs (including naphthalene) to the sea. In 2006, the discharge of PAHs from Offshore activities in Norway were approximately 67 tonnes of which 63 tonnes where naphthalene.

4. Desired reduction and identification of possible measures

The OSPAR objective with regard to hazardous substances is to prevent pollution of the maritime area by continuously reducing discharges, emissions and losses of hazardous substances. The ultimate aim is to achieve concentrations in the marine environment near background values for naturally occurring substances and close to zero for man-made synthetic substances. Every endeavour should be made to move towards the target of cessation of discharges, emissions and losses of hazardous substances of concern by the year 2020. According to the 1994 OSPAR Action Plan the national emissions of PAHs should be reduced by 50% or more during the period 1985 to 2000.

However, additional efforts are needed to address especially emissions to air from combustion processes but it will not be possible to eliminate all emissions. It is therefore doubtful that cessation target 2020 of releases can be achieved.

4.1 Existing measures

Environmental requirements on PAHs have earlier been set in the following OSPAR documents:

- PARCOM Recommendation 90/1 on the Definition of the Best Available Technology for Secondary Iron and Steel Plants.

[3] PAHs are reported as ΣPAH_9 including the following PAHs: anthracene; benzo[a]anthracene; benzo[*ghi*]perylene; benzo[a]pyrene; chrysene; fluoranthene; indeno[1,2,3-*cd*]pyrene; pyrene; phenanthrene.

- PARCOM Recommendation 91/2 on the Definition of the Best Available Technology in the Primary Iron and Steel Industry.
- PARCOM Recommendation 92/1 on Best Available Technology for Plants Producing Anodes and for New Electrolysis Installations in the Primary Aluminium Industry;
- PARCOM Recommendation 92/2 concerning Limitation of Pollution from New Primary Iron and Steel Production Installations.
- PARCOM Recommendation 93/1 concerning Limitation of Pollution from Existing Primary Iron and Steel Production Installations.
- PARCOM Recommendation 94/1 on Best Available Techniques for New Aluminium Electrolysis Plants;
- PARCOM Recommendation 94/4 on Best Available Techniques for the Organic Chemical Industry*
- PARCOM Recommendation 96/4 for the Phasing Out of the Use of One-Component Coal Tar Coating Systems for Inland Ships and the OSPAR Policy in Regard to Two-Component Coating Systems Containing PAHs (reference number: 1997-10).
- PARCOM Recommendation 97/2 on Measures to be Taken to Prevent or Reduce Emissions of Heavy Metals and Persistent Organic Pollutants Due to Large Combustion Plants ($\geq$ 50 MWth)
- OSPAR Recommendation 98/2 on Emission and Discharge Limit Values for Existing Aluminium Electrolysis Plants;
- OSPAR Recommendation 2002/1 on Discharge Limit Values for Existing Aluminium Electrolysis Plants

According to the North Sea Declarations of 1990 and 1995, the input of several hazardous substances, including PAHs, had to be reduced with 50 % or more in the period 1985 - 2000 from North Sea States.

Existing Directives of the European Community on emission control of PAHs are as follows:

- Council Directive 96/61/EC concerning integrated pollution protection and control applied to various types of industrial activities, Directive of the European Parliament and of the Council 2000/76/EC on waste incineration and Commission Directive 1999/31/EC on the landfill of waste, all indirectly controlling the emissions of PAHs. According to Directive 96/61/EC industrial pollution shall e.g. be operated using best available techniques. Directive 2000/76 sets emission limit values for particles and total organic matter from incineration of all types of waste, and Directive 1999/31/EC provides measures, procedures and guidance to prevent or reduce pollution of surface waters, groundwater, soil and air from landfills of waste;
- Council Directive 94/60/EC amending for the 14th time Council Directive 76/769/EEC on the approximation of the laws, regulations and administrative provisions of the Member States relating to restrictions on the marketing and use of certain dangerous substances and preparations, (includes limit values for concentrations of benzo(a)pyrene in creosote and coal tar. In an amendment, Council Directive 2001/90/EC, creosote may not be used in preservation of wood and wood so treated may not be placed on the market (with some exceptions: industrial installations and professional in situ re-treatment, old previously treated wood). In addition more stringent limit values are proposed for the content of benzo(a)pyrene in creosote used. A new amendment, Council Directive 2005/69/EEC, restrict the marketing and use of PAH in extender oils and tyres;
- According to the Council Directive 98/8/EC (the Biocide directive) wood preservation should be evaluated in the first phase of the review programme with evaluations of submitted data starting in 2004. A draft risk assessment for creosote has been made by the rapporteur country, Sweden. Discussions regarding acceptance of future use areas of creosote are still ongoing. So far, creosote is regulated through the Council Directive 76/769/EC.

* Reservation from the United Kingdom

- A daughter directive (Council Directive 2004/107/EC) under Council Directive 96/62/EC on ambient air quality assessment and management include PAHs. A target value for benzo(a)pyrene in ambient air is established and common methods and criteria for the assessment of PAH concentrations in ambient air and deposition of PAH has been determined.
- Directive 2000/60/EC of the European Parliament and of the Council includes inter alia specific measures against discharges, emissions and losses of priority substances, and cessation or phasing out of discharges, emissions and losses of priority hazardous substances. The list of priority substances as agreed on by the Council on 7 June 2001, includes polyaromatic hydrocarbons (identified as priority hazardous substances) and anthracene and naphthalene. With respect to priority substances, the European Commission shall submit proposals of controls for the progressive reduction in particular the cessation or phasing out of discharges, emissions and losses of priority hazardous substances. Hazardous substances are defined in the Water Framework Directive as "substances or groups of substances that are toxic, persistent and liable to bio-accumulate, and other substances or groups of substances which give rise to an equivalent level of concern". The amendment of the list of priority substances by Directive 2008/105/EC identifies naphthalene as priority substance and polyaromatic hydrocarbons as a group as well as anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(ghi)perylene, benzo(k)fluoranthene and indeno-(1,2,3-cd)pyrene as priority hazardous substances.
- The European Committee for Standardisation (CEN) has worked out emission standards for solid fuel residential combustion appliances (stoves, cookers, boilers and open fires places and inserts). These standards were issued as voluntary standards in 2001. EU Directive 2005/32/EC will establish a framework for setting eco-design requirements (such as emissions and energy efficiency requirements) for all energy using products. The directive will contribute to sustainable development by increasing energy efficiency and the level of protection of the environment. It will be followed by implementing measures which will establish the eco-design requirements. In principle, the Directive applies to all energy using products (except vehicles for transport) and covers all energy sources.

4.2 Possible measures

The diffuse emissions of PAHs are relatively high compared to those from point sources. Combustion of solid fuel in small domestic solid fuel combustion appliances is a considerable diffuse source of PAHs which can reduce the air quality in the local environment. In some countries (at least in Norway and Sweden) stove and/or boiler emission standards have been introduced. In order to implement the best available technique concept also for small combustion units the European Committee for Standardisation (CEN) has worked out emission guidelines for residential solid fuel stoves, cookers, boilers and open fire places and inserts. These voluntary guidelines were issued in 2001. The Council and the European Parliament have adopted a Commission proposal for a Directive (2005/32/EC) on establishing a framework for setting Eco-design requirements for all energy using products in the residential, tertiary and industrial sectors. Coherent EU-wide rules for eco-design will ensure that disparities among national regulations do not become obstacles to intra-EU trade. The directive does not introduce directly binding requirements for specific products, but does define conditions and criteria for setting requirements regarding environmentally relevant product characteristics (such as energy consumption) and allows them to be improved quickly and efficiently. It will be followed by implementing measures which will establish the eco-design requirements. In principle, the Directive applies to all energy using products (except vehicles for transport) and covers all energy sources. Additional OSPAR regulation will therefore not be needed.

Emissions from creosote treated timber have also been a considerable diffuse source of PAHs. However, as a consequence of the implementation of the EC Directives controlling creosote (see section 4.1), the use of creosote treated timber will probably to a large extent be phased out in Europe. The implementation of Commission Directive 1999/31/EC (landfill of waste) will make provision for low emissions of PAHs from creosote treated waste wood on landfills. Additional OSPAR recommendations will then not be needed.

Road traffic will be covered by recommended control measures worked out by the UN-ECE in the 1998 Protocol to the 1970 Convention on Long Range Transboundary Air Pollution on Persistent Organic Pollutants. This includes primary measures like fuel quality specifications, engine modifications as well as secondary measures like addition of exhaust treatment systems (oxidizing catalysts or particle traps). The increased use of three-ways catalyst in cars will reduce emissions of PAHs to air from road transport. Further reductions can be achieved by limiting the content of PAHs in diesel fuel. However, measures worked out by OSPAR might be of minor importance compared to the measures that have been worked out by the UN-ECE and the EU. The EU has restricted the content of PAHs in diesel fuel by setting a limit value of 11 % w/w of PAHs in diesel from the year 2000. The European Parliament has suggested tightening this limit considerably from 2009. In Sweden the PAH content in diesel fuel is already restricted. Therefore additional measures taken by OSPAR in order to reduce emission of PAHs from road traffic are not considered necessary.

Although there are uncertainties about the discharge figures from offshore activities, the offshore PAH discharges seem to be relatively high. Until now, little attention has been given to emissions and discharges of PAHs offshore. As noted in Chapter 2, there is 100 tonnes/year of PAHs including naphthalene, that are discharged from offshore installations. Most of these discharges arise in produced water. However, Norwegian water column monitoring shows that there is little biological impact of these quantities of PAHs offshore. Volume reductions (*i.e*. injection of produced water and water shut-off) or development of new end-of-pipe technology for reduction of dissolved components (including PAHs) of produced water will reduce the discharges of PAHs from the offshore industry. OSPAR's Offshore Industry Committee (OIC) is carrying out an assessment of the discharges of aromatic compounds including PAHs via produced water from the offshore industry. This study will give better information on the actual discharges of such compounds and will guide the OSPAR Commission in setting target standards for such compounds.

5. Choice for action / measures

OSPAR has agreed that Norway as lead country should prepare a draft recommendation on BEP for reduction of emissions of PAHs from domestic solid fuel combustion appliances. However, for the reasons mentioned in Section 4.2, such a BEP would not be needed if PAH pollution reduction measures are established by CEN (or other organisations). Drafting of such a BEP recommendation should therefore not be necessary due to EU's proposal on a Directive applying to all energy sources.

OSPAR has agreed that Norway as lead country should prepare a draft recommendation on BEP for the prevention or reduction of releases of PAHs from the use of creosote-treated timber. However, for the reasons mentioned in Section 4.2 (2nd paragraph), such a BEP would not be needed if PAH pollution reduction measures are taken by the EC. It is therefore recommended that drafting of such a BEP recommendation should not be undertaken because the amendment to Council Directive 76/769/EEC (restrictions) entered into force in the EU Member States in 2003.

OSPAR agreed that Norway should examine and assess the EC IPPC BAT reference document (BREF) on the non-ferrous sector in particular with respect to the aluminium industry. Norway also carried out a measuring programme for, and intercalibration exercise between different Söderberg plants with regard to discharges into water of PAHs (as Borneff 6). With this information as a basis, the Working Group on Point and Diffuse Sources examined, as recommended by OSPAR, the work on additional emission limit values for existing aluminium electrolysis plants.

In 2008, HSC examined an overview assessment report made by Norway on compliance with recommendations on best available techniques for aluminium electrolysis plants and anode plants. HSC agreed that further reporting could cease because the environmental level had been achieved and the recommendations of OSPAR for this industry have been taken care of by the EU IPPC BREF document.

The Contracting Parties are encouraged to use the most stringent BAT and support additional measures in the EC and other appropriate international frameworks to improve pollution abatement.

PAHs are emitted to air and discharged to water from offshore installations, but no complete survey of the total amount of emissions and discharges is available. Therefore

- a study to identify sources and quantify amounts of emissions and discharges of PAHs from offshore installations; should be arranged and
- based on that study, it should be further identified which measures for the reduction of such emissions and discharges of PAHs are needed, and which sources on the installations to focus on.

OSPAR 2001 adopted OSPAR Recommendation 2001/1 for the Management of Produced Water from Offshore Installations. Implementation of this and any possible subsequent programmes and measures, may result in a reduction of the discharges of PAHs, including naphthalene, from produced water from offshore installations.

For PAHs, there is thus a great variety of sources which contribute to the input to the maritime area. In addition, the significance of the sources also seems to differ between the different countries.

Contracting Parties should report in the next intersessional period quantitative data on discharges, emissions and losses of PAHs from significant sources in order to enable a first assessment of progress towards the 2020 target for hazardous substances and the identification of the need for further action.

OSPAR should monitor the progress for the development of EC IPPC BREFs within the framework of Council Directive 96/61/EC (IPPC), the implementation of Directive 2000/76/EC (waste incineration) and Commission Directive 1999/31/EC (landfill of waste), the amendment of Council Directive 76/769/EEC, the CEN work, the EC measures on the PAH content in diesel fuel and the UN ECE LRTAP work on road traffic, and the further work on PAHs which are identified as priority hazardous substances within the Water Framework Directive.

- In the context of the EC IPPC BREF for the primary iron and steel industry, OSPAR should pay particular attention to progress in the implementation of this BREF and the relevant PARCOM measures with a focus on PAHs.
- It has later been concluded that the EC IPPC BREF shall be reviewed in 2010/2011, and that in light of this process, OSPAR agreed that no further OSPAR measures on waste incineration and landfills of waste are required.
- Regarding the UN ECE LRTAP work on air emissions from road traffic measures are recommended for reducing emissions from mobile sources, e.g. emission limit values for new vehicles and for fuel, including control measures of PAH emissions from motor vehicles. For the amendment of Council Directive 76/769/EEC, the CEN work and the EC measures on PAH in diesel fuel, see under Section 3.4.

On 7 June 2001 a common position was reached on the Decision of the European Parliament and of the Council establishing the list of priority substances in the field of water policy, and PAHs were identified as priority hazardous substances within the Water Framework Directive. The OSPAR Commission should therefore request the European Commission to take account of the recommendations set out in this background document in the formulation of relevant measures.

Control measures for PAH apply under the EC POPs Regulation 850/2001/EC implementing the Stockholm POPs Convention and the UN ECE LRTAP POPs Protocol. The Regulation entered into force in 2004 and EU Member States are in the process of developing national action plans.

To ensure that the information in this background document can be considered in the context of other international agreements and EU measures which deal with hazardous substances.

Regarding further measures on PAH, OSPAR concluded in 2009;

- The majority of PAHs are released by incomplete combustion of fossil fuels and wood. Sources in industry are the manufacture of aluminium and coke ovens. Emissions may also occur via evaporation or leaching from PAH containing materials. Point sources have been regulated, but total elimination of PAH releases is difficult to regulate. Restriction on the use of creosote treated wood has reduced the importance of this source for diffuse releases of PAHs.
- There are still substantial releases to air and water. Data on discharges, emissions and losses of PAH is of poor quality for various reasons. An overall trend in releases is not possible to give. However, for some sources, reductions have been achieved due to technical improvements e.g. in the aluminium production. There is indication that in some sectors and for some Contracting Parties emissions to air might be stagnant or even increasing.
- It is expected that new and stricter emission limits for cars and trucks in the EU will reduce the PAH emission from this diffuse source. The full and effective implementation of the Water Framework Directive for PAHs will also support further reduction in releases.

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Annex 1: Reported emissions to air and discharges to water of PAHs from the Contracting Parties **(Ref. 1 - 5, 7, 8, 12)**

Table A.1: *PAH emissions to air from point sources (tonnes/year). The number of PAH compounds included in the data are given in brackets*

Point sources	The Netherlands (1992/-3)[4]	Germany (1994)	Belgium (1993)	United Kingdom	Norway (1994/95)	Sweden (1994)	Denmark (1999)	Finland (1995)	Switzerland (1995)
Primary aluminium industry	> 1 (10 PAH)	0,6 (BaP)	no activity	550 (16 US-EPA PAH, 1997)	51.5 (16 PAH)	2,3 (16 PAH)	No activity		0,3[5] (6 PAH)
Power generation	12 (10 PAH)	0,006 (BaP)	0,3 (10 PAH)	5,8 [6] (6/7 PAH) [7] [8]	0	0	0,05 (4 PAH)		0,17[9]
Iron and steel industry	> 22 [10](10 PAH)	1,4 (BaP)	1,9 (10 PAH)	[4]	no activity	0,4 (20 PAH)	~0		0,015 (2 PAH)
Ferroalloy industry	minor em.		no info.		0,7 (22 PAH)	minor em.	no activity		
Shipyards	4 (10 PAH)	no info.	3,9 (10 PAH)		minor em.	no info.	no info.		no activity
Creosote production	minor em.	no info.	no info.		no activity	no activity	< 1 g/year (16 PAH)		no activity
Prod. of creosote treated timber	17 (10 PAH)	0,1 (BaP)	220 (10 PAH)	no info.	minor em.	no info.	no activity	4,7 [11] (10 PAH)	
Coke ovens	4)	0,002 (B(a)P)	1,6 (10 PAH)	120 (16 EPA-PAH, 1997)	no activity	1 (20 PAH?, 1995)	no activity		
Cable burning	0	no activity	no info.		no activity	no activity	no activity		no activity
Chemical industries	48 (10 PAH)						~0 (4 PAH)		
Carbide production					0,8 (32 PAH)		no activity		

[4] The total emissions of PAH (10 PAH from diffuse and point sources) in 1999 was 709 tonnes.

[5] Reported emission from secondary Al-industry makes up another 0,4 t/a.

[6] Including emissions from combustion of coal (3,1 t/a) and oil (2,7 t/a).

[7] Emission of 16 tonnes PAH (16 EPA-PAH) in 1997 from electricity supply industry, waste incineration, and iron & steel works.

[8] Emission of 240 tonnes PAH (16 EPA-PAH) in 1997 from industrial coal combustion, commercial and institutional.

[9] The number represents 0,01 t/a from combustion in energy production and 0,16 t/a from combustion in industry.

[10] Including emissions from both iron and steel industry and coke ovens.

[11] Including emission from use of creosote treated timber.

Point sources	The Netherlands (1992/-3)4	Germany (1994)	Belgium (1993)	United Kingdom	Norway (1994/95)	Sweden (1994)	Denmark (1999)	Finland (1995)	Switzerland (1995)
Anode production		minor em.			2,4 (16 PAH)		no activity		
Municipal waste incineration			0,6 (10 PAH)	[4]	0,65 (PAH)	1 (20 PAH?, 1995)	1,3 (1994)		
Prod. of carbolineum treated timber*			36,1 (10 PAH)				no activity		
Pulp and paper ind. (comb. wood)					9,7 (15 PAH)		~0		

***Table A.2**: PAH emissions to air from diffuse sources (tonnes/year). The number of PAH compounds included are given in brackets*
It is not appropriate to compare the Contracting Parties due to different reporting on PAH-groups.

Diffuse sources	The Netherlands (1994)[12]	Germany (1994)	Belgium (1993)	United Kingdom	Norway (1993)	Sweden (1995)	Denmark (1999)	Finland (1995)	Switzerland (1995)
Wood burning stoves	81 (10 PAH)	1,9 (BaP)	3,9 (10 PAH)	200 (16 EPA-PAH, 1997)	60 (15 PAH)	100 (20 PAH?)	5,8 (4 PAH)	75 (15 PAH)	5[13](4 PAH)
Domestic coal combustion	minor em.	4,0 (BaP)		260 (16 EPA-PAH, 1997)	no activity		0,3 (4 PAH)		0,2 (6 PAH)
Domestic oil combustion	minor em.	3,4 (BaP)			3,4 (? PAH)		1,2 (4 PAH)	1,6 (15 PAH)	0,8 (6 PAH)
Ship coatings	6 (10 PAH)	no info.	minor em.[14]		minor em.		no info.		no activity
Road traffic	170 (10 PAH)	0,5-5,8 (BaP)	260 (10 PAH)	158 (16 EPA-PAH, 1997)	7,2 [15] (11 - 16 PAH)	50 (20 PAH?)	2,8 (4 PAH)	92 (10 PAH)	0,25 – 1,54 (6 PAH)
Use of creosote-treated timber[16]	173[17] (10 PAH)	0,06 (BaP)	no info.	100 (16 EPA-PAH, 1997)	no info		no info.		< 7,5 (6 PAH)
Road construction. (dust)	0[18]	no info.	108,2 (10 PAH)		0,55 (PAH)		no info.		0,5 (5 PAH)[19]
Domestic heating (oil/coal/ gas)		7,4 (BaP)	5,1 (10 PAH)				0,048 (4 PAH)		
Industrial heating including wood		0,03 (BaP)	7,6 (10 PAH)				0,978 (4 PAH)		
Stubble burning				6,3 (16 EPA-PAH, 1997)	1,6 (PAH)		0		
Air traffic					No info		0,06 (4 PAH)		

12 The total emissions of PAH (10 PAH from diffuse and point sources) in 1999 was 709 tonnes.

13 Emission factor : 3,5 g/t (ref. Corinair Emission Inventory Guide Book 1999 (UN-ECE-PAH)).

14 Referring to river transport.

15 Not defined mixture of PAH.

16 Consumption of creosote for timber treatment in Germany: 17 000 t (1988), Sweden: 2 500 t/a, Norway 1 018 t/a, UK: 30 000 t/a.

17 Including emissions from brushing creosote (95 t/a) and creosoted wood (78 t/a).

18 Based on construction of new roads.

19 Emission due to abrasion of tar modified surface layers. Tar modified bitumen was used in Switzerland until 1991.

Table A.3: *PAH discharges to water from point sources (tonnes/year). The number of PAH compounds included are given in brackets.*
It is not appropriate to compare the Contracting Parties due to different reporting on PAH-groups.

Point sources	The Netherlands (1993/94) [20]	Germany (1994)	Belgium (1993)	United Kingdom	Norway (1994)	Sweden (1994)	Denmark	Finland (1995)	Switzerland (1995)
Primary aluminium industry	1,2 (10 PAH)	no info.	no activity		7,3 (16 PAH)		no activity		
Power generation		no info.	minor em.		0		no info.		
Iron and steel industry	0,1 (6 PAH)	no info.	minor em.		no activity		no info.		
Ferroalloy industry		no info.	no info.	< 1,5 (? PAH)	0,3 (22 PAH)		no activity		
Shipyards	0,2 (6 PAH)	no info.	1,1 (10 PAH)		minor em.		no info.		
Creosote production	minor em.	minor em.	no info.		no activity	no activity	no activity		
Prod. of creosote treated timber	minor em	no info.	0,007 (10 PAH)		minor em.	no info.	no activity	0,005 (fluor-anthene)	
Coke ovens	0,8 (10 PAH)	no info.	1,0 (10 PAH)		no activity	0,4 (20 PAH)	no activity		
Cable burning	0	no activity	no info.		no activity	no activity	no activity		
Carbide production					2,6 (32 PAH)		no activity		minor em.
Anode production					1 (16 PAH)		no activity		
Municipal waste incineration			minor em.				no info.		
Refineries				no info.			no info.		
Municipal waste water				< 1 (?PAH)	0,18 (PAH[22])		0,08 (1994) (5 PAH)		
Offshore -prod. water -cutting				15,5 (?PAH)[21] 5,4 (?PAH)	11,6[22](PAH		2 (1998) (18 PAH)		

*) It is not appropriate to compare the Contracting Parties due to different reporting on PAH-groups.

[20] The total emissions of PAH (10 PAH from point and diffuse sources) was 14,6 tonnes.

[21] 64 tonnes in 1998.

[22] In 1996. 26 tonnes in 1998.

Table A.4: *PAH discharges to water from diffuse sources (tonnes/year). The number of PAH compounds included are given in brackets.*

Diffuse sources	The Netherlands (1993/94) [23]	Germany (1994)	Belgium (1993)	United Kingdom	Norway (1993)	Sweden (1994)	Denmark	Finland (1995)	Switzerland (1995)
Wood burning stoves	minor em.	no info.	minor em.		0		0		
Domestic coal combustion		no info.			0		0		
Domestic oil combustion		no info.			0		0		
Ship coatings	22 (10 PAH)	no info.[24]	10[25] (10 PAH)	< 1,5 (? PAH)	minor em.	5 (? PAH)	no info.		no activity
Road traffic	2,9 (6 PAH)	no info.	minor em.		0,32 (? PAH)		0,72 (1996) (18 PAH)	2,2[26] (6 PAH)	
Use of creosote-treated timber[27]	no info. 1,5 (fluor-anthene)	no info.				no info.	no info.		
Road construction	minor em.	no info.			0,14 [28](? PAH)		no info.		
Domestic heating (oil/coal/ gas)							~0		
Industrial heating including wood							no info.		
Stubble burning							no info.		
Air traffic							no info.		

23 The total emissions of PAH (10 PAH from point and diffuse sources) was 14,6 tonnes.

24 Approx. 1,5 t B(a)P applied in ship coatings.

25 River transport.

26 The estimate includes tires (0,24 t/a) and leakage of oil (1,96 t/a).

27 Consumption of creosote for timber treatment in Germany: 17 000 t (1988), Sweden: 2 500 t/a, Norway 1 018 t/a, UK: 30 000 t/a.

28 Road dust.

***Table A.5**: PAH air emissions (tonnes/year). 2000-2006.*

Officially reported emission data to EMEP from Contracting Parties.

It is not appropriate to compare data from different Contracting Parties due to different reporting methods

	2000	2001	2002	2003	2004	2005	2006
Belgium	2530	2320	2250	3360	2330	2410	2410
Denmark	90	100	100	110	120	140	140
Finland	150	160	170	170	170	130	130
France	320	300	270	280	270	250	240
Germany	900	990	940	950	970	1030	1010
Iceland *)	0	0	0	0	0	0	0
Ireland	-	-	120	110	110	110	-
Luxembourg	-	-	-	-	-	-	-
Netherlands	5440	4550	4130	4040	4660	4730	4620
Norway	140	150	170	130	140	160	-
Portugal	80	90	100	100	110	100	100
Spain	2790	2530	2200	2730	2520	2190	2180
Sweden	140	150	140	150	150	170	180
Switzerland	9,8	9,9	10	11	11	11	7
United Kingdom	160	170	140	130	120	110	110

*) the numbers from Iceland are in the range < 10^{-8} tonnes/year

Source: emep.emissions@umweltbundesamt.at and www.umweltbundesamt.at. 2008.

***Table A.6**: Emissions (tonnes/year) of Benzo(a)pyrene. 2000-2006.*

It is not appropriate to compare data from different Contracting Parties due to different reporting methods

Benzo[a]pyrene, tonnes/year	2000	2001	2002	2003	2004	2005	2006
Belgium	7.5	7.1	6.7	6.3	5.8	5.4	5.0
Denmark	2.7	2.9	2.8	3.2	3.4	4.1	4.0
Finland	4.6	4.9	5.1	5.0	5.0	4.0	4.0
France	9	8	7	8	7.4	6.9	6.6
Germany	33	36	35	35	35	38	37
Iceland	0.05	0.05	0.06	0.06	0.06	0.06	0.06
Ireland	3.3	3.3	3.3	3.1	2.9	3.0	3.0
Luxembourg	0.51	0.50	0.48	0.46	0.44	0.42	0.40
Netherlands	6.2	5.9	5.6	5.2	4.9	4.6	4.3
Norway	1.9	2.1	2.3	1.8	2.0	2.2	2.2
Portugal	2.5	2.7	2.9	3.0	3.1	3.0	3.1
Spain	27	26	25	24	23	22	20
Sweden	4.3	4.5	4.5	4.7	4.7	5.3	5.7
Switzerland	-	-	-	-	-	-	-
United Kingdom	5.7	5.7	4.8	4.2	3.9	3.5	3.6

Green = Official data on benzo(a)pyrene emissions
Other colours = Expert estimates

Source: EMEP 2008. Meteorological Synthesizing Centre-East (Moscow, Russia) as an international centre of Co-operative Programme for Monitoring and Evaluation of Long-Range Transmission of Air Pollutants in Europe (EMEP), www.msceast.org/pops/emission.

Annex 2: The PAH compounds defined regarding to some standards, agreements, etc.

PAH component1	CAS-No	PARCOM, Norwegian standard[2]	US EPA priority pollutants	Borneff [3]	AFNOR[4]	ECE-inventory guideline[5]	ECE LRTAP 1998[6]	Carcinogenicity [7]
Naphthalene	91-20-3		x			x		
2-Methyl naphthalene								
1-Methyl naphthalene								
Biphenyl	92-52-4							
Acenaphthylene	208-96-8							
Acenaphtene	83-32-9		x					
Dibenzofuran	132-64-9		x					
Fluorene	86-73-7		x					
Dibenzothiophene	132-65-0							
Phenanthrene	85-01-8	x	x			x		
Anthracene	120-12-7	x	x			x		
2-Methyl Phenanthrene								
2-Methyl Anthracene								
1-Methyl Phenanthrene								
Fluoranthene	206-44-0	x	x	x	x	x		
Pyrene	129-00-0	x	x			x		
Benzo(a)fluorene	238-84-6	x						
Benzo(b)fluorene		x						
Retene	483-65-8							
Benzo(ghi)fluoranthene								
Cyclopenta(cd)pyrene								
Benzo(a)anthracene	56-55-3	x	x			x		x
Chrysene (and triphenylene)	218-01-9/ 217-59-4	x	x (chrysene)		x	x		

PAH component1	CAS-No	PARCOM, Norwegian standard[2]	US EPA priority pollutants	Borneff [3]	AFNOR[4]	ECE-inventory guideline[5]	ECE LRTAP 1998[6]	Carcinogenicity [7]
Benzo(b)fluoranthene	205-99-2	x	x	x	x	x	x	x
Benzo(k)fluoranthene	207-08-9	x	x	x	x		x	x
Benzo(j)fluoranthene	205-82-3							x
Benzo(e)pyrene	192-97-2	x						
Benzo(a)pyrene	50-32-8	x	x	x	x	x	x	x
Perylene	198-55-0							
Indeno(1,2,3-cd)pyrene	193-39-5	x	x	x	x		x	x
Dibenzo(aj)anthracene								
Dibenzo(ah)anthracene	53-70-3	x	x		x	x		x
Benzo(ghi)perylene	191-24-2	x	x	x	x			
Dibenzo(a,e)pyrene	192-65-4	x						x
Dibenzo(a,h)pyrene	189-64-0	x						x
Dibenzo(a,i)pyrene	189-55-9	x						x
Anthanthrene	191-26-4							
Coronene	191-07-1					x		

1 PAH compounds, including the bicyclic compounds naphthalene and biphenyl, traditionally analysed.

2 As defined in PARCOM Recommendations 92/1, 94/1, 96/1, 98/2 for aluminium industry and aluminium electrolysis plants, and in the Norwegian Standard NS 9815.

3 Included in the so called Borneff 6.

4 The French governmental "official" definition since 1988.

5 Defined in the ECE-inventory Guideline, Prague 1995.

6 Monitored regarding UN ECE: 1998 Protocol to the 1970 Convention on Long-Range Transboundary Air Pollution on Persistent Organic Pollutants.

7 The carcinogenic PAH components according to IARC (1987).

Annex 3: Monitoring strategy for Polycyclic Aromatic Hydrocarbons

As part of the Joint Assessment and Monitoring Programme (*reference number 2003-22*), OSPAR 2004 adopted an Agreement on monitoring strategies for OSPAR Chemicals for Priority Chemicals (*reference number 2004-15*) to implement the following monitoring for tracking progress towards the objectives of the OSPAR Hazardous Substances Strategy (*reference number 2003-21*) with regard to polycyclic aromatic hydrocarbons. The Monitoring Strategy for polycyclic aromatic hydrocarbons will be updated as and when necessary, and redirected in the light of subsequent experience.

The releases of PAH to both air and water are still significant and monitoring of both sources and levels in marine environment are relevant in order to check progress. Most sources can be monitored, however for some it is more difficult and there is a general lack of data *e.g.* ships, harbour sediments.

There are a number of relevant controls (*e.g.* regulations, directives, recommendations and decisions) on a) marketing and/or use, b) emissions and/or discharges of PAHs which have been agreed by Contracting Parties both in OSPAR and in other international forums and have been highlighted as important measures for achieving the OSPAR Hazardous Substances objective with respect to PAHs in the "choice for actions" chapter of the Background Document. Evidence from reports on the implementation of such measures will be used to make an initial judgement of the extent to which the amounts of the substance emitted or discharged are likely to have been reduced. This will include consideration of the following OSPAR implementation reports:

a. OSPAR recommendation 2001/1 for the Management of Produced Water from Offshore Installations;

b. PARCOM Recommendation 94/1 on Best Available Techniques for New Aluminium Electrolysis Plants;

c. OSPAR Recommendation 98/2 on Emission and Discharge Limit Values for Existing Aluminium Electrolysis Plants;

d. PARCOM Recommendation 96/4 for the Phasing Out of the Use of One-Component Coal Tar Coating Systems for Inland Ships and the OSPAR Policy in Regard to Two-Component Coating Systems Containing PAHs (reference number: 1997-10);

e. PARCOM Recommendation 93/1 concerning Limitation of Pollution from Existing Primary and Steel Production Installations.

For air emissions OSPAR will seek to make best use of data reported in other forums. The yearly reporting to EMEP of releases to air in the context of UNECE LRTAP may in principle provide data for PAH for all significant sources to air. OSPAR will examine and assess these data as to determine whether emissions trends are decreasing. In addition, emissions from sources subject to IPPC reported to the EPER database will be examined.

For discharges to water, data for IPPC activities will be reported through EPER. For other significant sources there is no emission inventory taking place on a regular basis. As an additional activity national data for discharges from non-IPPC sources could be collected at regular intervals. However, not all Contracting Parties have the resources to contribute to such reporting so it should be considered as an additional voluntary monitoring activity. The list of indicative sources at Annex 2 of the Background Document for PAH should be taken into account in any initiative to collect this information. Contracting Parties carrying out such additional monitoring are urged to co-ordinate their activities. Sources not covered by EPER where significant contributions of PAH can be expected

include: transport and infrastructure; building materials; offshore activities; waste/disposal (incl. wastewater); contaminated land and sediments.

Information about production/sales/use of PAH compounds will be updated on a regular basis in relation with the update of the Background Document taking account *inter alia* of information from European Chemicals Agency (ECHA), use/sales statistics from industry and registrations in Nordic or other (national) product registers (creosote, tar). For some types of products where diffuse releases are relevant, sales or use figures might be reported voluntarily on a national basis as a part of the quantitative data for some sources for discharges to water.

As the resources available for environmental monitoring are limited, OSPAR will maintain the status of PAHs as voluntary determinands under CAMP and RID for the time being.

Under the CEMP, monitoring of PAHs in sediments and biota (mussels) will continue. ICES has developed technical annex for monitoring of alkylated PAH and assessment criteria will be developed in the 2009-2010 meeting cycle. Contracting Parties should be encouraged to extend their monitoring programmes to cover alkylated PAHs and to report results on a voluntary basis through the data-handling mechanism operated by ICES for the CEMP.

OSPAR will also seek to make use of results from monitoring for PAHs under the Water Framework Directive.

OSPAR reports on the dumping of dredged material will be taken into account in relation with other secondary sources.

POLYAROMATIC HYDROCARBONS (PAHS) MONITORING STRATEGY[29]	
Implementation of actions and measures	• Examination of progress in the implementation of regulations on marketing and/or use or emission and/or discharge which have been agreed, or are endorsed, by the Background Document
Emissions to air	• Examination and assessment of trends in emissions to air as reported annually by Contracting Parties to the UNECE/EMEP database in the context of the LRTAP Convention and, for IPPC sources, to EPER
Discharges and losses to water	• Examination and assessment of trends in discharges to water from IPPC sources in data reported annually by Contracting Parties to EPER *Additional voluntary activities:* • *Estimation of data on discharges to water from sources not covered by EPER*
Production/use/sales /figures	• The lead country will update information on production, sales and use of products containing PAHs during review statements of the Background Document when necessary.
Atmospheric inputs	• *Monitoring will continue under the CAMP, as a voluntary determinand*
Riverine inputs	• *Monitoring will continue under the RID, as a voluntary determinand*
Inputs from the offshore industry	• Continued reporting through the implementation reporting on OSPAR Recommendation 2001/1 for the Management of Produced Water from Offshore Installations
Maritime area:	
Dredged materials	• Continued reporting to OSPAR of the concentrations of PAHs in dredged materials disposed to the maritime area
Concentrations in sediments and biota	• Monitoring will continue under the CEMP • Contracting Parties will be encouraged to extend their monitoring programmes to cover alkylated PAHs and to report results on a voluntary basis through the data-handling mechanism operated by ICES for the CEMP
Concentrations in water	• Where available, data will be periodically compiled from EC WFD monitoring
Biological effects	• Monitoring will continue under the CEMP

[29] The development of the information collection system, guidelines and assessment tools for this strategy will need to take into account which PAHs are monitored in each section of this strategy.

New Court
48 Carey Street
London WC2A 2JQ
United Kingdom

t: +44 (0)20 7430 5200
f: +44 (0)20 7430 5225
e: secretariat@ospar.org
www.ospar.org

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