COAL-TAR PITCH, HIGH TEMPERATURE

CAS No: 65996-93-2

EINECS No: 266-028-2

SUMMARY RISK ASSESSMENT REPORT

Environment

Final report, May 2008

The Netherlands

Rapporteur for the risk assessment of COAL-TAR PITCH, high temperature is The Netherlands

Contact point:

Bureau REACH
P.O. Box 1
3720 BA Bilthoven
The Netherlands

Date of Last Literature Search:	**2007**
Review of report by MS Technical Experts finalised:	**May 2008**
Final report:	**2008**

PREFACE

This report provides a summary, with conclusions, of the risk assessment report of the substance COAL-TAR PITCH, high temperature that has been prepared by The Netherlands in the context of Council Regulation (EEC) No. 793/93 on the evaluation and control of existing substances.

For detailed information on the risk assessment principles and procedures followed, the underlying data and the literature references the reader is referred to the comprehensive Final Risk Assessment Report (Final RAR) that can be obtained from the European Chemicals Bureau[1]. The Final RAR should be used for citation purposes rather than this present Summary Report.

Outline of the risk assessment

Coal tar pitch, high temperature (CTPHT) possibly contains thousands of substances that may all be relevant for the receiving environment. It is however the Rapporteurs' opinion that the assessment should be focused on the risk of the emission of polycyclic aromatic hydrocarbons (PAHs) only, since this was the main reason to put CTPHT on the 3rd priority list. Moreover, based on the available information, it is only for the EPA 16 homocyclic PAHs that sufficient effect - and exposure data are available. It is for this reason that the risk assessment of CTPHT is restricted to this group of PAHs and regards them as representative for the total emission of PAH, accepting that the potential risk of CTPHT might be underestimated.

Since so many unintentional sources contribute to the total emission of PAHs into the environment, which by extension are not related to production and use of CTPHT, the risk assessment will only be focussed on the PAHs that is emitted by producers and the down stream users of CTPHT on a local scale. To put this emission into perspective, the calculated local concentrations have been related to the background levels measured in urban and rural areas.

---

[1] European Chemicals Bureau – Existing Chemicals – http://ecb.jrc.it

CONTENTS

TABLES

1 GENERAL SUBSTANCE INFORMATION

1.1 IDENTIFICATION OF THE SUBSTANCE

CAS Number: 65996-32-2
EINECS Number: 266-028-2
IUPAC Name: Coal Tar Pitch, High temperature

1.2 PURITY/IMPURITIES, ADDITIVES

The content of the sixteen EPA PAHs in pitch used for impregnation and binding is presented in Table 1.1. Most relevant for the risk assessment is the composition for binder pitch, as it is the main source for the production of anodes and electrodes.

Table 1.1 PAH content in CTPHT (16 EPA PAH and other aromatic hydrocarbons). Method used is DIN 51920 for softening point and ISO 6998 for coking value

	Impregnation Pitch	Binder Pitch
	[mg/kg]	**[mg/kg]**
Aromatic hydrocarbons		
Acenaphthene	390	432
Fluorene	144	472
2-Methylfluorene	50	112
1-Methylfluorene	n.d.	61
Phenanthrene	3874	6299
Anthracene	737	1311
Cyclopenta[def]phenanthrene	918	821
Fluoranthene	17389	10789
Acephenanthrylene	828	386
Pyrene	14849	9449
Benzo(a)fluorene	4509	1974
Benzo(b)fluorene	4306	2456
Benz(a)anthracene	15008	7715
Chrysene	14041	8053
Benzo(b)fluoranthene	17408	12131
Benzo(k)fluoranthene	8704	6065
Benzo[e]pyrene	11891	8976
Benzo(a)pyrene	12924	10021
Perylene	5014	3167
Dibenz(a,h)anthracene	2209	1749
Indeno(1,2,3-cd)pyrene	11106	9061
Benzo(ghi)perylene	9945	8664
Anthantrene	4581	3464
Tar acids / phenolics	n.d.	n.d.
Tar bases / nitrogen-containing heterocycles		
Acridine	242	264
Carbazole	1556	1664
Sulfur-containing heterocycles		
Dibenzothiophene	269	438

	Impregnation Pitch	Binder Pitch
	[mg/kg]	**[mg/kg]**
Oxygen-containing heterocycles / furans		
Dibenzofuran	n.d.	215
Total	**162.892**	**116.209**

1.3 PHYSICO-CHEMICAL PROPERTIES

The physico-chemical characteristics of pitch are presented in Table 1.2.

Table 1.2 Physico-chemical properties of CTPHT

Property	Value	Comment / Reference
Physical state (at ambient temperature)	black solid	
Melting point [°C]	65 - 150 °C	softening range; CCSG 2006*
Boiling point [°C]	>360 °C	at 1013 hPa
Density [g/m^3]	1.15 – 1.40	at 20 °C; ASTM D 71; CCSG 2006*
Vapour pressure [hPa]	< 0.1	at 20 °C;
	< 10	at 200 °C; OECD 104; CCSG 2006*
Water solubility [mg/L]	~0.040	16 EPA PAHs, at a loading of 10 g/L at 22 °C; RÜTGERS VFT 1999
Partition coefficient n-octanol/water (log value)	--	not applicable
Flash point [°C]	>250	ISO 2719; CCSG 2006*
Autoflammability [°C]	>450	ignition point at 1013 hPa; DIN 51794 ; CCSG 2006*
Explosive properties	not explosive	CCSG 2006*
Oxidizing properties	not oxidizing	CCSG 2006*

**CCSG 2006: Internal communication, Coal Chemicals Sector Group/CEFIC 2006*

Water solubility

Within the scope of a comprehensive analytical programme on the availability of PAH from pitch in water (RÜTGERS VFT 1999), a column containing 10 g of finely powdered pitch (20 - 200 µm) was force-perculated by 1.1 L of tap water (water recycling for 1 wk). Each experimental period was terminated by withdrawal of 1 L of the extract and renewal of the volume by fresh-water exchange of 1 l each. After the first run, 36.5 µg PAH/L were found; after 15 cycles, the PAH decreased to 11.8 µg/L, and after 39 cycles to 0.9 µg/L. The first water-soluble fraction was dominated by the presence of acenaphthene, phenanthrene, fluoranthene, and pyrene, followed by naphthalene and fluorene. All other PAHs were distinctly below 1 µg/L. The total cumulative amount of water-extractable EPA PAHs amounted to approx. 370 µg/10g (= ~0.004 %).

Table 1.4. Physico-chemical properties of various PAHs

Substance	CAS nr	Molecular formula	Molecular weight (g.mol^{-1})	Melting point (°C)	Boiling point (°C)	Water solubility (µg.l^{-1})*	Log K_{ow} (-)	Vapour pressure (Pa at 25 °C)	Density (kg.l^{-1})_	Henry's constant (Pa m^3/mol at 25 °C)
Naphthalene	91-20-3	$C_{10}H_8$	128.2	81	217.9^{c}	31900^{a}	3.34^{c}	11.2^{g}	1.154	50^{l}
Acenaphthene	208-96-8	$C_{12}H_8$	154.2	96	278	3910^{b}	4.00^{e}	3.3×10^{-1h}	0.899	14.3^{l}
Acenaphthylene	91-20-3	$C_{12}H_{10}$	150.2	92	279	16100^{b}	3.62^{f}	4.8×10^{-1i}	1.024	11.5^{l}
Fluorene	86-73-7	$C_{13}H_{10}$	166.2	115-116	295^{e}	1800^{a}	4.22^{e}	8.3×10^{-2i}	1.203	8.5^{l}
Anthracene	120-12-7	$C_{14}H_{10}$	178.2	216.4	342^{e}	47^{a}	4.68^{d}	9.4×10^{-4i}	1.283	4.3^{l}
Phenanthrene	85-01-8	$C_{14}H_{10}$	178.2	100.5	340	974^{a}	4.57^{d}	2.6×10^{-2i}	0.980	3.7^{l}
Fluoranthene	206-44-0	$C_{16}H_{10}$	202.3	108.8	375	200^{a}	5.20^{d}	1.2×10^{-3h}	1.252	1.1^{o}
Pyrene	129-00-0	$C_{16}H_{10}$	202.3	156	360	125^{a}	4.98^{e}	1.0×10^{-3i}	1.271	1.4^{n}
Benzo(a)anthracene	56-55-3	$C_{18}H_{12}$	228.3	160.7	435	10.2^{a}	5.91^{d}	7.6×10^{-6i}	1.226	0.81^{p}
Chrysene	218-01-9	$C_{18}H_{12}$	228.3	253.8	448	1.65^{a}	5.81^{d}	5.7×10^{-7j}	1.274	0.079^{q}
Benzo(a)pyrene	50-32-8	$C_{20}H_{12}$	252.3	175	496	1.54^{a}	6.13^{d}	7.3×10^{-7j}	1.35	$0.034^{o(20\,°C)}$
Benzo(b)fluoranthene	205-99-2	$C_{20}H_{12}$	252.3	168.3	481	1.28^{a}	6.12^{f}	3.3×10^{-6k}	-	$0.051^{o(20\,°C)}$
Benzo(k)fluoranthene	207-08-9	$C_{20}H_{12}$	252.3	217	480	0.93^{a}	6.11^{d}	1.3×10^{-7k}	-	$0.043^{o(20\,°C)}$
Benzo(ghi)perylene	191-24-2	$C_{22}H_{12}$	276.3	277	545^{i}	0.14^{a}	6.22^{d}	$1.4 \times 10^{-8\,j}$	1.329	$0.027^{o(20\,°C)}$
Dibenzo(a,h)anthracene	53-70-3	$C_{22}H_{14}$	278.4	266.6	524	0.82^{b}	6.50^{e}	3.7×10^{-10j}	1.282	$1.3.10^{-4q}$
Indeno(1,2,3-cd)pyrene	193-39-5	$C_{22}H_{12}$	276.3	163.6	536	0.1*	6.58^{f}	1.7×10^{-8k}	-	0.046^{q}

The data presented in the table were taken form Mackay et al. (1992) The selected values for water solubility were preferably based on generated column methods (a) and in absent on shake-flask (b) using geometric means (* for indeno(1,2,3-cd)pyrene no data were available, a default value of 0.1 µg/l was used). The selected values for log Kow were preferably based on slow-stirring/generator column (c) or slow-stirring methods (d) using average values. If absent the log Kow values were based on the shake-flask method (e), or in absent of data calculated using ClogP model (f). The selected values for vapour pressure were based on manometry/gas saturation (g), gas saturation (h), gas saturation/effusion (i), effusion method (j) using geometric means or estimated using EPIWIN (k). The selected values for the Henry's constant were based on batch/gas stripping/wetted-wall column (l), batch stripping/wetted-wall column (m), batch/gas stripping (n), gas stripping (o), batch column (p) using geometric means or when no data were available, constants were calculated using EUSES 2.0 (q).

1.4 CLASSIFICATION

Proposed Classification and Labelling:

Symbols: N

R-phrases: R50/53

S-phrases: S60, 61

CTPHT is a complex mixture containing many compounds, such as homo- and heterocyclic aromatic hydrocarbons. As a consequence, it is very difficult to classify CTPHT on the basis of the individual compounds. In addition, not all the substances can be analyzed when diluted in water. Furthermore, the different CTPHT components influence each others solubility in the water phase and consequently the composition in the water phase will not be the same at different loadings. Therefore, the WAF approach is considered most appropriate to classify CTPHT, as recommended for oil products and products such as creosote in the OECD Guidance document on aquatic toxicity testing of difficult substances and mixtures (series on testing and assessment Number 23). It was however concluded that limited data is available on the preparation and aquatic toxicity testing of WAFs of CTPHT. Hence, it proved to be impossible to draw any definitive conclusions on the aquatic classification and labelling of CTPHT taking the preferred WAF approach. Therefore, it was decided to base the aquatic classification and labelling of CTPHT upon the rules laid down in the Dangerous Preparations Directive (DPD) (1999/45/EEC), which is the first choice as a suitable alternative in this case. CTPHT is considered as a 'preparation' in this perspective. In the last Adaptation to Technical Progress of the DPD (2006/8/EC) concentration limits are provided for classification of preparations containing substances that are very toxic to the aquatic environment (N;R50/53). The 16 individual EPA PAHs were analysed with respect to their acute aquatic effects data and the lowest available EC50 or LC50 was chosen as a point of departure for aquatic hazard classification.

2 GENERAL INFORMATION ON EXPOSURE

Production

Within the European Union, high temperature coal tar pitch is produced by ten companies at eleven sites in nine countries. The total European Union production capacity in 2004 was 1,127,000 tonnes. The actual production output of coal tar pitch in that year was about 817,800 tonnes. Import from outside the EU was reported to be about 91,600 tonnes per year and export was about 355,600 tonnes per year. The total consumption of coal tar pitch in the EU from these figures is estimated to be about 554,000 tonnes per year

Uses

Coal tar pitch is mainly used as a binding agent in the production of carbon electrodes, anodes and Søderberg electrodes for instance for the aluminium industry. It is also used as a binding agent for refractories, clay pigeons, active carbon, coal briquetting, road construction and roofing. Furthermore small quantities are used for heavy duty corrosion protection, see Table 2.1

Table 2.1 Use pattern for coal tar pitch. Sales in the EU in 2003.

Application	Industry category 1)	Use category 2)	Quantity (tonnes/year)	Percentage of total sales
Anodes	8	2	322 500	71.3
Electrodes	8	2	81 400	18.0
Refractories	0	2	22 500	5.0
Road construction	16	2	800	0.2
Active carbon	0	2	7 900	1.7
Heavy duty corrosion protection	14	2/39	4 700	1.0
Roofing	16	2	3 200	0.7
Clay pigeons	0	2	5 800	1.3
Coal briquetting	9	2	3 700	0.9
Total			452 400	100

1) industrial category 0 is others, industrial category 8 metal extraction, refining and processing industry, industrial category 9 is mineral oil and fuel industry, industrial category 14 is paints, lacquers and varnishes industry, industrial category 16 is engineering industries: civil and mechanical

2) use category 2 is adhesives and binding agents and use category 39 is non-agricultural biocides

The exposure assessment has been focussed on the emission of PAHs on a local scale for production of coal tar pitch and the main applications, primarily because lower emissions for the other sources are expected. Moreover, the amounts of coal tar pitch used for roofing and road paving decrease as it is replaced by petroleum pitch on account of the lower PAH content (worker hygiene). Some manufacturers claim to produce “environmentally” friendly clay pigeons by applying petroleum pitch in order to meet the EEC environmental protection directives, or apply no binder at all.

The emission of PAHs at coke ovens are not considered because coal tar is produced at this process. Coal tar is used as a feedstock for the production of coal tar pitch and therefore the coke ovens are not part of the life cycle of coal tar pitch which actually starts at the production stage of coal tar pitch.

With respect to the main applications of coal tar pitch, the following point sources are considered:

- Anode production
- Aluminium production applying prebakes (with and without) anode baking.
- Aluminium production using Søderberg technology
- Graphite electrode production
- Production of steel, silicon, etc., applying electric arc furnaces with Søderberg electrodes.

Trends

The future consumption of pitches depends not only on human health risks and environmental hazards but also on economics due to progress of science and technology.

Since more than ten years a new technology has been developed at benchscale based on inert anodes to replace CTPHT-bound carbonated anodes but this technology is still immature and costly. Therefore, it can be expected that CTPHT will be used for more than decades in the primary aluminium smelters.

For refractories, the pitch industry now proposes pitches with a higher softening point resulting in a benzo(a)pyrene (B(a)P) content of 300 ppm compared to currents levels in pitches ranging up to 20,000 ppm.

Most of the European countries have banned CTPHT in the road construction by law or agreement between trade unions and road building companies. In fact only very particular applications such as kerosene proof coatings for parking lots, airfields and taxi ways still use pitch as an emulsion. This market is decreasing and represents only 200 tonnes of pitch per year.

Pitch bound active carbons are more and more produced outside the EU and are anyway processed in closed vessels where the pitch is pyrolyzed to pure carbon with controlled emissions.

Roofing and corrosion protection with CTPHT-based products are declining dramatically and a phasing out of these artefacts is predicted in the next few years. However, information provided by industry contradicts the assumption that the use of CTPHT in heavy duty corrosion protection has been reduced significantly and that in the short term this application will be phased out.

The use of pitch bound coal briquettes is forbidden in some countries (Germany and Scandinavia). This market is also linked to dedicated and captive users in mining countries (France and Belgium) where retired miners have rights on solid fuels provided by the former state owned companies. Capacities of 2,000 ktonnes/year of briquettes existing in the early 80’s in Europe are now decreased to 150 ktonnes/year, also using more environmental friendly binders like starch and molasses. Also here a full phasing out of the use of CTPHT can be expected in the next few years. However, recent information provided by industry contradicts the assumption that the use of CTPHT in coal briquetting will be phased out.

Clay pigeons manufacturers, claiming environmental protection, displaced carbopitch by petrochemical binders for more than 80% of their production and the former clay pigeons being exported outside the European Union. However, information provided by industry contradicts the assumption that the use of CTPHT in clay pigeons has been reduced significantly and that in the short term this application will be phased out.

In summary, the pitch market, decreasing in Europe for economical reasons, will remain only for electrodes, anodes and graphite artefacts

3 ENVIRONMENT

3.1 ENVIRONMENTAL EXPOSURE

Environmental releases

PAH may enter the environment from both natural (forest fires, volcanoes) and anthropogenic sources. The latter includes production and use of coal tar pitch itself, but PAH is also formed as a by-product during other industrial processes (e.g. coke plants). The emissions of PAH from other sources are mainly characterised by combustion processes and by particular industrial processes using PAH-containing compounds such as coal, crude oil, creosote, coal-tar or bitumen. Important non-industrial sources of PAH emissions are the combustion of solid fuels, like wood, peat and coal and the use of all automotive fuels but in particular diesel oil. Natural sources of PAH include the accidental burning of forests, woodland, heath etc. Another natural PAH source is volcanic activity, but no data is available regarding these emissions. A recent overview of the PAH emissions to air in the EU is not available and the data available is only based on a few EU countries. Nevertheless, it seems that the largest emission sources to air are non-industrial, like domestic combustion, the use of coal tar-based products and road transport. For the emission to surface water even less data is available. Some industrial point sources can be large emission sources of PAH. Compared to (industrial) point source data, the emission via atmospheric deposition seems more important.

Site specific data was available for the CTPHT producing companies, anode production and primary aluminium production applying Søderberg and prebake anodes. The risk assessment for the other applications of CTPHT is based on generic (realistic worst case) scenarios. For most of the production sites complete emission profiles for all EPA 16 PAHs were provided for both water and air. If absent, the emission rates were related to sites with comparable operational management. With respect to the application of CTPHT, emission rates were either provided by industry (production of anodes and electrodes, aluminium production) or obtained from literature. For all applications the information was limited to only a number of PAHs, not specified PAH totals or to B(a)P only. Therefore, emission rates for the rest of the 16 EPA PAHs were determined using typical profile of the 16 EPA PAHs for the process of concern. For the anode and graphite production and aluminium production based on Søderberg technology these profiles were provided by industry, if needed completed with information found in literature. For production of ferro-alloys profiles were obtained from open literature.

Coal tar pitch is produced from coal tar at coal tar processing facilities. At these facilities many other products, essentially different kinds of oils are produced. All these different production steps contributed to the total release of PAHs by the facility. As coal tar pitch is the final product, which remains after several distillation steps it is difficult to consider it separate from all the other production steps in coal tar processing. Therefore it should be noted that the reported figures do not concern the production of coal tar pitch per se, but the whole process of coal tar processing.

Environmental fate

Degradation

A detailed description of the biodegradation of PAHs is given in the RAR. On the basis of model calculations, Mackay *et al*. (1992) ranked the 16 EPA PAH according to their persistence in, water, soil and sediment in different classes (Table 3.1) which correspond to a specific half-live in these compartments (Table 3.2). For the risk assessment these values are used.

Table 3.1. Ranking of PAH in different classes

Compound	Water	Soil	Sediment
Naphthalene	3	5	6
Acenaphthene*)	3	5	6
Acenaphthylene*)	3	5	6
Fluorene	4	6	7
Anthracene	4	6	7
Phenanthrene	4	6	7
Fluoranthene	4	7	8
Pyrene	5	7	8
Benzo(a)anthracene	5	7	8
Chrysene	5	7	8
Benzo(a)pyrene	5	7	8
Benzo(b)fluoranthene*)	5	7	8
Benzo(k)fluoranthene	5	7	8
Benzo(ghi)perylene*)	5	7	8
Dibenzo(a,h)anthracene	5	7	8
Indeno(1,2,3-cd)pyrene	5	7	8

Table 3.2. Suggested half-life classes of PAHs in various environmental compartments (Mackay et al., 1992).

Class	Half-life (h)	
	Mean	Range
1	17	10-30
2	55	30-100
3	170	100-300
4	550	300-1000
5	1700	1000-3000 (42 -125 days)
6	5500	3000-10000 (125 – 420 days)
7	17000	10000-30000 (420 – 1250 days)
8	55000	> 30000

Adsorption

Many studies have been performed to determine the organic carbon-water partition coefficient (K_{oc}) of aromatic hydrocarbons, both monoaromatic and polycylic compounds. A well known relationship between K_{oc} and K_{ow} is the following equation of Karickhoff *et al.* (1979) based on experiments with 10 compounds of which 8 are non-halogenated aromatic compounds, mostly PAHs, in three sediments.

The last years, more evidence becomes available that sorption of organic chemicals into soils and sediments can be better described by a two-phase model. Research in this field is still on-going. To be able to use this two-phase sorption model, it is important to know the fraction of black carbon and the fraction of amorphous organic carbon. It should also be noted that the quantification of carbonaceous materials still suffers from operational shortcomings (Cornelissen et al., 2005). Thus, although the two-phase model seems to be an improvement over the one-phase model, in practice it can only be used when black carbon is measured. This is very site-specific. Moreover, care should be given to the fact that when partition coefficients for the 'pure' OC phases are combined, this exceeds the actual, experimentally measured sorption. Thus, K_{BC} values for pure BC are not necessarily valid under in situ conditions, probably due to attenuation effects by DOM molecules (Koelmans et al., 2006). For the purpose of the RAR the one-phase model as proposed by Karickhoff et al. (1979), which incorporates field-derived sediments with mixtures of all types of organic carbon (including both black carbon and amorphous organic carbon), is used to derive 'general'.

Koc values for the different PAHs (see Table 3.3).

Table 3.3 The log Koc for the 16 EPA PAHs based on the equation of Karickhoff et al. (1979)

Compound	Log Kow	Log Koc
Naphthalene	3.34	3.13
Acenaphthene	4.00	3.79
Acenaphthylene	3.62	3.41
Fluorene	4.22	4.01
Anthracene	4.68	4.47
Phenanthrene	4.57	4.36
Fluoranthene	5.20	4.99
Pyrene	4.98	4.77
Benzo(a)anthracene	5.91	5.70
Chrysene	5.81	5.60
Benzo(a)pyrene	6.13	5.92
Benzo(b)fluoranthene	6.12	5.92
Benzo(k)fluoranthene	6.11	5.90
Benzo(ghi)perylene	6.22	6.01
Dibenzo(a,h)anthracene	6.50	6.29
Indeno(1,2,3-cd)pyrene	6.58	6.37

Factors influencing the sorption and bioavailability of PAHs

Several studies indicate that bioavailability decreases with increasing residence time. The extent of aging seems to be dependent on the organic carbon content. As no ageing effect were found at an organic carbon content of standard soil (2%) and the fact that this phenomenon is insufficiently quantifiable, aging is not considered in the risk assessment.
The adsorption and desorption of PAHs to carbonaceous materials can show a high degree of variation, likely as a result of the origin of the organic carbon to which the PAHs are associated. Consequently, strong sorbing carbonaceous materials may limit the bioavailability of PAHs to soil and sediment species. However, the implication for risk assessment of coal tar pitch is as yet difficult to interpret. In addition, the effect of the sorption on carbonaceous materials on uptake of PAHs by biota is still unclear. Where some studies show that uptake of PAHs is significantly decreased in the presence of carbonaceous materials, others show that this effect is not present or negligible.
Based on these considerations and the uncertainties on this topic, it was decided not to include a correction for binding to soot-like materials in the risk assessment.

Precipitation

This information on precipitation is in conformity with the estimated distribution using EUSES 2.0, which was used for the current risk assessment

Distribution in sewage treatment plants

The distribution of the 16 EPA PAHs in sewage treatment plants has been calculated using the model SIMPLETREAT integrated to EUSES (EC, 2004) based on the Koc values and the Henry's low constants presented in Table 3.3 and Table 1.6, respectively. They are presented as an example in Table 3.4.

Table 3.4 Estimation of removal of the 16 EPA in STP according to EUSES 2.0

nr	PAH compound	% to air	% to water*	% to sludge	% degraded	% removal
1	Naphthalene	38.7	47.2	12.6	1.5	52.8
2	Acenaphthene	11.0	47.4	40.3	1.3	52.6
3	Acenaphthylene	12.4	62.8	22.9	1.8	37.2
4	Fluorene	5.7	41.6	52	0.3	58.4
5	Anthracene	1.5	25.2	73.1	0.2	74.8
6	Phenanthrene	1.6	29	69.2	0.2	71.0
7	Fluoranthene	0.1	14.3	85.5	0.1	85.7
8	Pyrene	0.3	18	81.7	0.0	82.0
9	Benzo(a)anthracene	0.0	9.3	90.7	0.0	90.7
10	Chrysene	0.0	9.6	90.3	0.0	90.4
11	Benzo(a)pyrene	0.0	8.8	91.2	0.0	91.2
12	Benzo(b)fluoranthene	0.0	8.8	91.2	0.0	91.2
13	Benzo(k)fluoranthene	0.0	8.8	91.2	0.0	91.2
14	Benzo(ghi)perylene	0.0	8.7	91.3	0.0	91.3
15	Dibenzo[a.h]anthracene	0.0	8.3	91.7	0.0	91.7
16	Indeno(1,2,3-cd)pyrene	0.0	8.3	91.7	0.0	91.7

* % to water is equal to parameter Fstp used in section 3.1.5.1

Bioaccumulation

An evaluation of the available data on bioaccumulation of PAHs in fish and mussels has been made. For fish the following reliable range of BCF values were found: Naphthalene: 302 – 999; Acenaphthene: 387; Fluorene: 1050 – 3500; Anthracene: 900 – 6760; Phenanthrene: 700 – 6760; Fluoranthene: 3388 – 14836; Pyrene: 50 – 11300; Benzo(a)-anthracene: 200 – 265; Benzo(a)pyrene: 608.
For mussels the following reliable range of BCF values were found: Anthracene: 345 - 380189; Phenanthrene: 1240 - 1280; Fluoranthene: 5920 – 4120 ; Pyrene: 1054 - 43000; Benzo(a)-anthracene: 41000 – 142000.

It was concluded that the EP can be considered to estimate the maximum amount that can be taken up by earthworms, but the total variation in body residues and uptake kinetics may be driven differences in assimilation efficiencies between soils, as well as differences in desorption kinetics of PAHs from soils. The BCF values calculated based on the equation presented are therefore considered as a reasonable worst case for earthworms

There are several indications that biomagnification of PAHs does not occur in both the aquatic and terrestrial environment, partly being the result of the relatively high rates of metabolism and excretion of PAHs in vertebrates and some invertebrates. Nevertheless, species from the lower trophic levels that are not able to effectively metabolize these compounds may exhibit food web transfer.

Environmental concentrations

Water compartment

In view of the strong contribution of the unintentional sources to the regional background concentration, it was decided to present Clocal and PEC regional separately to get a better understanding of the additional risk that is caused by the emission sources under investigation. As sufficient monitoring data are available no separate calculation of the regional PECs had been performed. Since the different PAH emission sources are already mapped by several authorities it is not expected that a comparison between calculated regional PECs and monitoring data would elucidate that a significant emission source is overlooked.

Production

The local concentration in surface water and sediment for the different production sites are given in Table 3.5 and Table 3.6, respectively. For all sites, except site 3 and 5, site specific information on river flow is available. For these sites the dilution factor is set accordingly. For site 3 and 5 de default dilution factor as recommended in the EU TGD (2003) is applied: 10 for fresh water and 100 for marine water. When the reported on-site emissions are discharged to off-site wastewater treatment facilities (STP) the STP-model is used in the calculations with the appropriate effluent flow of the off-site STP (site 1, 3, 5 and 7).

Table 3.5 Local concentration during emission episode in surface water ($ng.l^{-1}$) for the production sites.

Substance/Site	1*	3**	4*	5*	6*	7*	8*	9*
Naphthalene	0.0045	0.27	0.7	2.1	0.68	0.037	2.9	1.0
Acenaphthene	0.00086	0.03	0.4	0.72	0.35	0.0081	2.5	0.5
Acenaphthylene	n.d.	0.07	1.6	3.7	0.046	0.010	2.3	0.5
Fluorene	0.0006	0.03	0.4	0.69	0.19	0.015	0.3	0.5
Anthracene	0.00011	0.05	0.7	0.81	0.22	0.0045	0.1	0.5
Phenanthrene	0.0010	0.03	1.1	0.016	0.58	0.069	0.4	0.5
Fluoranthene	0.00034	0.02	5.0	0.25	0.49	0.021	0.5	0.4
Pyrene	0.0019	0.08	3.9	0.22	0.31	0.024	0.6	0.5
Benzo(a)anthracene	0.000024	0.004	2.6	0.024	0.045	0.0043	0.1	0.6
Chrysene	0.000027	0.005	2.4	0.0034	0.046	0.0048	0.1	0.6
Benzo(a)pyrene	0.000017	0.006	7.6	0.0022	0.041	0.0031	0.0	0.9
Benzo(b)fluoranthene	0.000018	0.003	12.0	0.0023	0.031	0.0048	0.0	0.5
Benzo(k)fluoranthene	0.000018	0.003	3.8	0.0023	0.028	0.0016	0.0	0.5
Benzo(ghi)perylene	0.000015	0.002	4.2	0.0019	0.018	0.0023	0.0	0.8
Dibenzo(a,h)anthracene	0.000009	0.0	0.8	0.0012	0.014	0.00037	0.0	0.5
Indeno(1,2,3-cd)pyrene	0.000008	0.001	2.6	0.0010	0.011	0.0015	0.0	0.5

*) concentration in fresh water; **) concentration in marine water

Table 3.6 Local concentration during emission episode in sediment (μg.kg$_{dwt}^{-1}$) for the production sites.

Substance/Site	1*	3**	4*	5*	6*	7*	8*	9*
Naphthalene	0.00064	0.0003	0.10	0.83	0.10	0.0060	0.45	0.14
Acenaphthene	0.00055	0.022	0.27	1.2	0.23	0.0055	1.7	0.31
Acenaphthylene	n.d.	0.020	0.46	2.7	0.013	0.0029	0.64	0.13
Fluorene	0.00060	0.035	0.44	2.0	0.21	0.017	0.35	0.51
Anthracene	0.00033	0.19	2.4	6.9	0.69	0.015	0.31	1.4
Phenanthrene	0.0024	0.065	2.8	0.10	1.4	0.17	1.1	1.1
Fluoranthene	0.0034	0.26	55	6.9	5.1	0.23	5.1	4.3
Pyrene	0.012	0.53	26	3.7	2.0	0.16	3.9	2.7
Benzo(a)anthracene	0.0012	0.23	147	3.5	2.4	0.23	6.4	29
Chrysene	0.0011	0.21	110	0.38	2.0	0.21	4.6	25
Benzo(a)pyrene	0.0015	0.27	736	0.51	3.7	0.29	2.8	78
Benzo(b)fluoranthene	0.0015	0.23	1104	0.51	2.7	0.43	2.9	38
Benzo(k)fluoranthene	0.0015	0.23	345	0.51	2.3	0.14	2.9	38
Benzo(ghi)perylene	0.0016	0.30	506	0.55	2.0	0.26	2.0	83
Dibenzo(a,h)anthracene	0.0019	0.36	166	0.64	2.9	0.078	1.5	101
Indeno(1,2,3-cd)pyrene	0.0020	0.37	690	0.69	2.8	0.38	1.7	106

*) concentration in freshwater sediment; **) concentration in marine sediment

Industrial/professional use

With respect to the industrial uses considered the emissions are specified in the fraction dissolved and bound to particles. Based on the considerations given above and the uncertainties on this topic, it was decided not to include a correction for binding to soot-like materials in the current risk assessment. Therefore, the calculation of the concentration in surface water and sediment will be based on the total concentration in effluent and the partitioning based on the coefficients presented above.

The concentration in sea/fresh water and marine/fresh water sediment for the Ferro-alloy production plants is given in Table 3.7. As mentioned in section 3.1.3.2.2 the release of PAHs from graphite is considered negligible. For primary aluminium production and anode baking facilities these are presented in Table 3.8 and Table 3.9, respectively.

Table 3.7 Local concentrations during emission episode in sea water, marine sediment, fresh water, and fresh water sediment for ferro-alloy producing industry.

Substance	Sea water (ng.l^{-1})	Marine sediment (μg.kgdwt^{-1})
Naphthalene	0.5	0.1
Acenaphthene	2.8	1.7
Acenaphthylene	0.5	0.1
Fluorene	1.6	1.7

Substance	Sea water ($ng.l^{-1}$)	Marine sediment ($\mu g.kgdwt^{-1}$)
Anthracene	33	10.0
Phenanthrene	18.8	42.0
Fluoranthene	27.5	266.5
Pyrene	17.4	107.2
Benzo(a)anthracene	2.8	140.5
Chrysene	5.9	240.5
Benzo(a)pyrene	1.0	79.7
Benzo(b)fluoranthene	1.9	153.5
Benzo(k)fluoranthene	NA	NA
Benzo(ghi)perylene	0.4	42.0
Dibenzo(a,h)anthracene	0.1	21.7
Indeno(1,2,3-cd)pyrene	0.2	53.6

Ferro-alloy: Ferro-alloy production (including paste preparation)

Table 3.8 Local concentrations in water (fresh and marine) during the emission episode (ng.l^{-1}) for primary aluminium production and anode baking facilities.

Use category	Site	Naphthalene	Acenaphthene	Acenaphthylene	Fluorene	Anthracene	Phenanthrene	Fluoranthene	Pyrene	Benz(a)anthracene	Chrysene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(k)fluoranthene	Benzo(ghi)perylene	Dibenzo(a,h)anthracene	Indeno(1,2,3-cd)pyrene
VSS II	S1	5.8E+00	2.4E+01	5.8E+00	1.6E+01	2.1E+01	1.9E+02	2.6E+02	1.6E+02	2.8E+01	5.4E+01	8.5E+00	2.6E+01		3.8E+00	1.0E+00	2.2E+00
VSS II	S3	1.7E+00	7.2E+00	1.7E+00	4.5E+00	6.0E+00	5.5E+01	7.6E+01	4.8E+01	8.2E+00	1.6E+01	2.5E+00	7.6E+00		1.1E+00	3.0E-01	6.4E-01
VSS II	S4	1.8E+02	7.4E+02	1.8E+02	4.7E+02	6.2E+02	5.7E+03	7.8E+03	5.0E+03	8.5E+02	1.6E+03	2.6E+02	7.9E+02		1.1E+02	3.1E+01	6.6E+01
SWPB	P7	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
VSS I	S5	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
VSS I	S6	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
PB+Anode I	PA1 1)	1.0E+01	4.2E+01	1.0E+01	2.7E+01	3.3E+02	1.2E+03	6.9E+02	5.3E+02	8.1E+01	7.0E+01	1.5E+01	3.2E+01		4.0E+00	3.4E+00	3.0E+00
PB+Anode I	PA2	1.6E+01	6.7E+01	1.6E+01	4.2E+01	5.3E+02	1.9E+03	1.1E+03	8.3E+02	1.3E+02	1.1E+02	2.4E+01	5.0E+01		6.3E+00	5.4E+00	4.7E+00
PB+Anode I	PA3	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
PB+Anode I	PA4	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
PB+Anode I	PA5	6.7E+01	2.8E+02	6.7E+01	1.7E+02	2.2E+03	8.0E+03	4.6E+03	3.5E+03	5.3E+02	4.6E+02	9.9E+01	2.1E+02		2.6E+01	2.3E+01	2.0E+01
PB+Anode I	PA6	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
PB+Anode I	PA7	4.5E+00	1.9E+01	4.5E+00	1.2E+01	1.5E+02	5.4E+02	3.1E+02	2.3E+02	3.6E+01	3.1E+01	6.7E+00	1.4E+01		1.8E+00	1.5E+00	1.3E+00
PB+Anode I	PA8	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
PB+Anode I	PA9	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
PB+Anode I	PA10	1.1E+00	4.6E+00	1.1E+00	2.9E+00	3.6E+01	1.3E+02	7.5E+01	5.7E+01	8.8E+00	7.5E+00	1.6E+00	3.5E+00		4.3E-01	3.7E-01	3.2E-01
PB+Anode I	PA11	4.0E-01	1.7E+00	4.0E-01	1.0E+00	1.3E+01	4.8E+01	2.7E+01	2.1E+01	3.2E+00	2.7E+00	5.9E-01	1.3E+00		1.6E-01	1.4E-01	1.2E-01
PB+Anode I	PA12 1)	3.2E-01	1.3E+00	3.2E-01	8.2E-01	1.0E+01	3.8E+01	2.1E+01	1.6E+01	2.5E+00	2.1E+00	4.6E-01	9.8E-01		1.2E-01	1.1E-01	9.2E-02
PB+Anode I	PA13	2.7E+01	1.1E+02	2.7E+01	7.1E+01	8.9E+02	3.2E+03	1.8E+03	1.4E+03	2.2E+02	1.9E+02	4.0E+01	8.5E+01		1.1E+01	9.1E+00	7.9E+00
PB+Anode I	PA14	2.5E+02	1.0E+03	2.5E+02	6.3E+02	8.0E+03	2.9E+04	1.7E+04	1.3E+04	1.9E+03	1.7E+03	3.6E+02	7.7E+02		9.6E+01	8.2E+01	7.1E+01
PB+Anode I	PA15	8.1E-03	3.3E-02	8.1E-03	2.1E-02	2.6E-01	9.6E-01	5.5E-01	4.2E-01	6.4E-02	5.5E-02	1.2E-02	2.5E-02		3.2E-03	2.7E-03	2.3E-03
Anode I	A1 1)	3.1E+02	1.3E+03	3.1E+02	8.1E+02	1.0E+04	3.7E+04	2.1E+04	1.6E+04	2.5E+03	2.1E+03	4.6E+02	9.8E+02		1.2E+02	1.0E+02	9.1E+01

1) concentration in fresh surface water. NE: no emission to water

Table 3.9 Local concentrations in sediment (fresh and marine) during the emission episode ($\mu g.kg_{dwt}^{-1}$) for primary aluminium production and anode baking.

Use category	Site	Naphthalene	Acenaphthene	Acenaphthylene	Fluorene	Anthracene	Phenanthrene	Fluoranthene	Pyrene	Benz(a)anthracene	Chrysene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(k)fluoranthene	Benzo(ghi)perylene	Dibenzo(a,h)anthracene	Indeno(1,2,3-cd)pyrene
VSS II	S1	8.0E-01	1.5E+01	1.5E+00	1.6E+01	6.1E+01	4.3E+02	2.5E+03	9.6E+02	1.4E+03	2.1E+03	7.1E+02	2.1E+03		3.9E+02	2.0E+02	5.1E+02
VSS II	S3	2.3E-01	4.4E+00	4.4E-01	4.7E+00	1.8E+01	1.3E+02	7.4E+02	2.8E+02	4.1E+02	6.3E+02	2.1E+02	6.2E+02		1.1E+02	5.8E+01	1.5E+02
VSS II	S4	2.4E+01	4.6E+02	4.6E+01	4.8E+02	1.8E+03	1.3E+04	7.7E+04	2.9E+04	4.2E+04	6.5E+04	2.2E+04	6.4E+04		1.2E+04	6.0E+03	1.5E+04
SWPB	P7	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
VSS I	S5	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
VSS I	S6	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
PB+Anode I	PA1 ~~1)~~	1.4E+00	2.6E+01	2.7E+00	2.7E+01	9.9E+02	2.8E+03	6.8E+03	3.1E+03	4.1E+03	2.8E+03	1.3E+03	2.6E+03		4.1E+02	6.7E+02	7.0E+02
PB+Anode I	PA2	2.2E+00	4.1E+01	4.2E+00	4.3E+01	1.6E+03	4.4E+03	1.1E+04	4.9E+03	6.4E+03	4.4E+03	2.0E+03	4.1E+03		6.4E+02	1.1E+03	1.1E+03
PB+Anode I	PA3	7.2E+00	1.6E+00	3.8E+00	9.8E-01	3.4E-01	4.4E-01	1.0E-01	1.7E-01	2.0E-02	2.5E-02	1.2E-02	1.2E-02		9.8E-03	5.1E-03	4.3E-03
PB+Anode I	PA4	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
PB+Anode I	PA5	9.4E+00	1.7E+02	1.8E+01	1.8E+02	6.5E+03	1.8E+04	4.4E+04	2.0E+04	2.7E+04	1.8E+04	8.2E+03	1.7E+04		2.7E+03	4.4E+03	4.6E+03
PB+Anode I	PA6	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
PB+Anode I	PA7	6.3E-01	1.2E+01	1.2E+00	1.2E+01	4.4E+02	1.2E+03	3.0E+03	1.4E+03	1.8E+03	1.2E+03	5.6E+02	1.2E+03		1.8E+02	3.0E+02	3.1E+02
PB+Anode I	PA8	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
PB+Anode I	PA9	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
PB+Anode I	PA10	1.5E-01	2.8E+00	2.9E-01	2.9E+00	1.1E+02	3.0E+02	7.3E+02	3.4E+02	4.4E+02	3.0E+02	1.4E+02	2.8E+02		4.4E+01	7.2E+01	7.5E+01
PB+Anode I	PA11	5.6E-02	1.0E+00	1.1E-01	1.1E+00	3.9E+01	1.1E+02	2.7E+02	1.2E+02	1.6E+02	1.1E+02	4.9E+01	1.0E+02		1.6E+01	2.6E+01	2.7E+01
PB+Anode I	PA12 1)	4.4E-02	8.1E-01	8.2E-02	8.3E-01	3.0E+01	8.6E+01	2.1E+02	9.6E+01	1.2E+02	8.5E+01	3.9E+01	8.0E+01		1.3E+01	2.1E+01	2.1E+01
PB+Anode I	PA13	3.8E+00	7.0E+01	7.1E+00	7.2E+01	2.6E+03	7.4E+03	1.8E+04	8.3E+03	1.1E+04	7.4E+03	3.3E+03	6.9E+03		1.1E+03	1.8E+03	1.9E+03
PB+Anode I	PA14	3.4E+01	6.3E+02	6.4E+01	6.5E+02	2.4E+04	6.7E+04	1.6E+05	7.5E+04	9.7E+04	6.6E+04	3.0E+04	6.2E+04		9.8E+03	1.6E+04	1.7E+04
PB+Anode I	PA15	1.1E-03	2.1E-02	2.1E-03	2.1E-02	7.8E-01	2.2E+00	5.3E+00	2.5E+00	3.2E+00	2.2E+00	9.9E-01	2.0E+00		3.2E-01	5.3E-01	5.5E-01
Anode I	A1 1)	4.3E+01	8.0E+02	8.2E+01	8.3E+02	3.0E+04	8.5E+04	2.1E+05	9.5E+04	1.2E+05	8.5E+04	3.8E+04	7.9E+04		1.2E+04	2.0E+04	2.1E+04

1) concentration in fresh surface water

As no monitoring data for the production site are available no comparison between predicted and measured levels can be made. In comparison to the regional concentrations reported in COMMPS database, the water concentration predicted for site 1 and 5 up to 9 were well lower. For site 4 the predicted water concentrations were comparable to the median values. The marine water concentration for site 3 was comparable to the BRCs reported by OSPAR.

The calculated local concentrations in sediment for site 1 and 5 up to 9 were well below the 90 percentile regional concentrations reported in COMMPS database. The predicted concentration for site 4 were much closer the 90perc. Of the COMMPS database, especially the high molecular PAHs. The predicted marine sediment concentrations for B(a)P, fluoranthene, benzo(b+k)fluoranthene and pyrene at site 3 were comparable or lower than the BRCs used by OSPAR. For the other PAHs no BRCs are given and consequently no comparison can be made.

Industrial use

In comparison to the background levels reported by OSPAR and measured on a reference site by Axelman *et al*. (1999), the local concentrations (Clocal) in marine water near anode and VSS plants and ferro alloy plants were much higher. Also the calculated local concentrations in fresh water were much higher in comparison to the mean values in EU rivers, whereas the Clocal in freshwater near ferro alloy plants is comparable to the mean values in the EU rivers, although the calculated local concentrations for fluoranthene were higher. In the absence of monitoring data, no comparison can be made for the Clocal near the emission points of anode plants and ferro-alloy plants. The monitoring data available in sea water in the vicinity for aluminium smelters using web scrubbers (Axelman *et al*., 1999) were comparable to those predicted when the different forms (dissolved, colloids and particles) are added.

The calculated local concentrations in sediment were for all applications much higher than the regional background concentrations, where the calculated local concentrations near ferro alloy plants were much closer to these values. Like for the water phase the monitoring data for sediment near emission points are limited to aluminium smelters. The Clocal for marine sediment near VSS plants is well within the range of B(a)P concentration measured in the vicinity near different smelters.

Terrestrial

Production

Only for those sites where emissions are directed to a municipal wastewater treatment plant the local concentrations (averaged over 30 days) in grassland and agricultural soil are the result of atmospheric deposition and sludge application. For a number of these sites the sludge is not spread on arable land but incinerated (i.e. site 1 and 3). For site 5 waste water is directed to an onsite industrial STP for which it is assumed that sludge is not used for agricultural purposes. Consequently, sludge-application to arable land is applicable to site 7 only. For the other sites the effluent is treated in on-site wastewater treatment facilities or directly discharged to water. For now it is assumed that for on-site wastewater treatment facilities sludge is treated as chemical waste and sludge is not allowed to be used on agricultural soil.

Industrial/professional use

The local concentrations (averaged over 30 days) in grassland and agricultural soil are the result of only atmospheric deposition as no waste water treatment of the (scrubber/cooling water) effluent was assumed. The route of waste water treatment sludge to agricultural soil therefore is not relevant for the generic scenarios. The concentrations predicted in agricultural soil and grassland at sites near the different downstream users are given in Table 3.12, Table 3.13 and Table 3.14.

Table 3.10 Local concentrations in agricultural soil averaged over 30 days ($ng.kg_{dwt}^{-1}$) for the production sites.

Substance/Site	1	3	4	5	6	7 1)	8	9
Naphthalene	221	2210	1053	988	121	51	143	130
Acenaphthene	34	88	31	208	18	9	21	21
Acenaphthylene	86	64	23	69	47	20	53	52
Fluorene	56	182	53	1287	30	22	35	34
Anthracene	51	101	20	715	27	17	31	31
Phenanthrene	143	611	72	4420	81	112	91	88
Fluoranthene	273	637	108	4030	156	208	169	169
Pyrene	208	364	70	728	113	169	130	126
Benzo(a)anthracene	442	390	121	819	247	169	273	260
Chrysene	494	780	130	1560	273	182	312	299
Benzo(a)pyrene	1690	1144	416	1014	884	416	1287	988
Benzo(b)fluoranthene	8190	5460	2080	598	4550	1950	5200	5070
Benzo(k)fluoranthene	2990	2600	793	1690	1560	663	1950	819
Benzo(ghi)perylene	702	546	182	923	364	208	416	416
Dibenzo(a,h)anthracene	2730	1950	702	1248	1560	611	2080	1690
Indeno(1,2,3-cd)pyrene	1209	910	312	988	650	338	1170	728

Table 3.11 Local concentrations (total) in grassland averaged over 180 days ($ng.kg_{dwt}^{-1}$) for the production sites.

Substance/Site	1	3	4	5	6	7 1)	8	9
Naphthalene	351	3380	1690	1560	195	77	221	208
Acenaphthene	66	169	60	403	36	16	42	40
Acenaphthylene	169	122	44	130	88	36	101	99
Fluorene	109	364	103	2470	60	27	68	65
Anthracene	100	208	40	1430	56	25	62	61
Phenanthrene	299	1196	143	8710	156	95	182	182
Fluoranthene	546	1287	221	8060	299	182	338	325
Pyrene	416	728	143	1430	221	143	260	247
Benzo(a)anthracene	897	780	247	1690	507	221	533	533
Chrysene	1001	1560	260	2990	533	247	611	598
Benzo(a)pyrene	3250	2340	832	2080	1820	728	2600	1950
Benzo(b)fluoranthene	16900	11050	4290	1209	9100	3640	10270	10010
Benzo(k)fluoranthene	5980	5200	1560	3510	3250	1261	3770	1690
Benzo(ghi)perylene	1430	1105	351	1820	741	325	845	819

Substance/Site	**1**	**3**	**4**	**5**	**6**	**7** [1)]	**8**	**9**
Dibenzo(a,h)anthracene	5590	3900	1430	2470	2990	1196	4160	3250
Indeno(1,2,3-cd)pyrene	2470	1820	624	1950	1300	546	2340	1430

1) Only for site 7 sludge from the municipal STP is spread on agricultural land.

Table 3.12 Local concentrations in agricultural soil over 30 days (ng.kg$_{dwt}$$^{-1}$) for primary aluminium production and anode baking.

Use cat.	Site	Naphthalene	Acenaphthene	Acenaphthylene	Fluorene	Anthracene	Phenanthrene	Fluoranthene	Pyrene	Benz(a)anthracene	Chrysene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(k)fluoranthene	Benzo(ghi)perylene	Dibenzo(a,h)anthracene	Indeno(1,2,3-cd)pyrene
VSS II	S1	6.7E+02	1.4E+02	3.3E+02	1.3E+03	4.2E+02	3.6E+03	5.7E+03	2.6E+03	3.4E+03	7.9E+03	7.7E+03	1.5E+04		4.7E+03	2.0E+03	5.0E+03
VSS II	S3	1.7E+03	3.5E+02	8.5E+02	3.4E+03	1.1E+03	9.3E+03	1.5E+04	6.7E+03	8.7E+03	2.0E+04	2.0E+04	3.7E+04		1.2E+04	5.2E+03	1.3E+04
VSS II	S4	1.8E+03	3.7E+02	9.0E+02	3.6E+03	1.1E+03	9.9E+03	1.6E+04	7.1E+03	9.3E+03	2.2E+04	2.1E+04	4.0E+04		1.3E+04	5.5E+03	1.4E+04
SWPB	P7	1.0E-02		3.9E+00	2.9E+00			6.8E+02	2.5E+02	5.5E+02	9.6E+02	6.0E+02	3.7E+02	7.0E+02	3.9E+02	1.7E+02	2.5E+02
VSS I	S5	1.9E+03	4.0E+02	9.4E+02	3.7E+03	8.3E+02	4.2E+03	6.2E+03	4.2E+03	8.8E+03	2.1E+04	2.2E+04	5.6E+04		1.6E+04	2.9E+03	1.4E+04
VSS I	S6	1.8E+03	3.8E+02	9.1E+02	3.5E+03	8.0E+02	4.1E+03	6.0E+03	4.1E+03	8.5E+03	2.0E+04	2.1E+04	5.5E+04		1.5E+04	2.8E+03	1.4E+04
Anode I	PA1	7.0E+02	1.3E+02	6.1E+00	7.9E+02	7.2E+02	4.1E+03	6.0E+03	3.0E+03	6.1E+03	1.4E+04	5.7E+03	2.6E+04		5.5E+03	5.8E+03	5.8E+03
Anode I	PA2	3.0E+02	5.5E+01	2.6E+00	3.4E+02	3.1E+02	1.7E+03	2.5E+03	1.3E+03	2.6E+03	6.1E+03	2.4E+03	1.1E+04		2.3E+03	2.5E+03	2.5E+03
Anode I	PA3	2.7E-01	5.0E-02	2.3E-03	3.1E-01	2.8E-01	1.6E+00	2.3E+00	1.2E+00	2.4E+00	5.6E+00	2.2E+00	1.0E+01		2.1E+00	2.2E+00	2.2E+00
Anode I	PA4	3.1E+01	5.7E+00	2.7E-01	3.5E+01	3.2E+01	1.8E+02	2.6E+02	1.3E+02	2.7E+02	6.3E+02	2.5E+02	1.1E+03		2.4E+02	2.6E+02	2.6E+02
Anode I	PA5	1.9E+02	3.5E+01	1.6E+00	2.1E+02	1.9E+02	1.1E+03	1.6E+03	8.1E+02	1.7E+03	3.9E+03	1.5E+03	7.0E+03		1.5E+03	1.6E+03	1.6E+03
Anode I	PA6	2,8E+01	5,1E+00	2,4E-01	3,1E+01	2,8E+01	1,6E+02	2,4E+02	1,2E+02	2,4E+02	5,7E+02	2,2E+02	1,0E+03		2,2E+02	2,3E+02	2,3E+02
Anode I	PA6	1.8E+03	3.4E+02	1.6E+01	2.1E+03	1.9E+03	1.1E+04	1.6E+04	7.8E+03	1.6E+04	3.7E+04	1.5E+04	6.7E+04		1.4E+04	1.5E+04	1.5E+04
Anode I	PA7	2.8E+01	5.1E+00	2.4E-01	3.1E+01	2.8E+01	1.6E+02	2.4E+02	1.2E+02	2.4E+02	5.7E+02	2.2E+02	1.0E+03		2.2E+02	2.3E+02	2.3E+02
Anode I	PA8	6.7E+00	1.2E+00	5.8E-02	7.6E+00	6.9E+00	4.0E+01	5.8E+01	2.9E+01	5.9E+01	1.4E+02	5.5E+01	2.5E+02		5.3E+01	5.6E+01	5.6E+01
Anode I	PA9	1.6E+04	2.9E+03	1.4E+02	1.8E+04	1.6E+04	9.3E+04	1.3E+05	6.8E+04	1.4E+05	3.3E+05	1.3E+05	5.8E+05		1.2E+05	1.3E+05	1.3E+05
Anode I	PA10	1.7E+02	3.2E+01	1.5E+00	2.0E+02	1.8E+02	1.0E+03	1.5E+03	7.6E+02	1.5E+03	3.6E+03	1.4E+03	6.5E+03		1.4E+03	1.5E+03	1.5E+03
Anode I	PA11	6.7E+02	1.2E+02	5.8E+00	7.6E+02	6.9E+02	3.9E+03	5.7E+03	2.9E+03	5.9E+03	1.4E+04	5.4E+03	2.5E+04		5.2E+03	5.6E+03	5.6E+03
Anode I	PA12	1.9E+01	3.5E+00	1.6E-01	2.1E+01	1.9E+01	1.1E+02	1.6E+02	8.2E+01	1.7E+02	3.9E+02	1.5E+02	7.0E+02		1.5E+02	1.6E+02	1.6E+02
Anode I	PA13	2.4E+03	4.5E+02	2.1E+01	2.7E+03	2.5E+03	1.4E+04	2.1E+04	1.0E+04	2.1E+04	5.0E+04	2.0E+04	9.0E+04		1.9E+04	2.0E+04	2.0E+04
Anode I	PA14	1.8E+03	3.4E+02	1.6E+01	2.1E+03	1.9E+03	1.1E+04	1.6E+04	7.8E+03	1.6E+04	3.7E+04	1.5E+04	6.7E+04		1.4E+04	1.5E+04	1.5E+04
Anode I	PA15	8.1E-01	1.5E-01	7.0E-03	9.2E-01	8.3E-01	4.7E+00	6.9E+00	3.5E+00	7.1E+00	1.7E+01	6.6E+00	3.0E+01		6.3E+00	6.7E+00	6.7E+00
Anode I	A1 [1)]	9.9E+03	1.8E+03	8.6E+01	1.1E+04	1.0E+04	5.8E+04	8.4E+04	4.3E+04	8.7E+04	2.0E+05	8.0E+04	3.7E+05		7.7E+04	8.2E+04	8.2E+04

Table 3.13 Local concentrations in grassland over 180 days (ng.kg$_{dwt}^{-1}$) for primary aluminium production and anode baking.

Use cat.	Site	Naphthalene	Acenaphthene	Acenaphthylene	Fluorene	Anthracene	Phenanthrene	Fluoranthene	Pyrene	Benz(a)anthracene	Chrysene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(k)fluoranthene	Benzo(ghi)perylene	Dibenzo(a,h)anthracene	Indeno(1,2,3-cd)pyrene
VSS II	S1	1.1E+03	2.7E+02	6.2E+02	2.6E+03	8.5E+02	7.4E+03	1.1E+04	5.1E+03	6.6E+03	1.6E+04	1.5E+04	2.8E+04		9.5E+03	4.0E+03	1.0E+04
VSS II	S3	2.7E+03	7.0E+02	1.6E+03	6.6E+03	2.2E+03	1.9E+04	2.9E+04	1.3E+04	1.7E+04	4.1E+04	3.9E+04	7.3E+04		2.5E+04	1.0E+04	2.6E+04
VSS II	S4	2.9E+03	7.5E+02	1.7E+03	7.0E+03	2.3E+03	2.0E+04	3.1E+04	1.4E+04	1.8E+04	4.3E+04	4.2E+04	7.8E+04		2.6E+04	1.1E+04	2.8E+04
SWPB	P7	1.6E-02		7.4E+00	5.7E+00			1.4E+03	5.1E+02	1.1E+03	1.9E+03	1.2E+03	7.4E+02	1.4E+03	7.6E+02	3.3E+02	5.1E+02
VSS I	S5	2.9E+03	7.7E+02	1.8E+03	7.3E+03	1.6E+03	8.5E+03	1.3E+04	8.5E+03	1.8E+04	4.2E+04	4.2E+04	1.1E+05		3.2E+04	5.8E+03	2.8E+04
VSS I	S6	2.8E+03	7.4E+02	1.7E+03	7.1E+03	1.6E+03	8.2E+03	1.2E+04	8.2E+03	1.7E+04	4.1E+04	4.1E+04	1.1E+05		3.1E+04	5.6E+03	2.7E+04
Anode I	PA1	1.1E+03	2.6E+02	1.1E+01	1.5E+03	1.4E+03	7.9E+03	1.2E+04	6.1E+03	1.2E+04	2.9E+04	1.2E+04	5.2E+04		1.1E+04	1.2E+04	1.2E+04
Anode I	PA2	4.6E+02	1.1E+02	4.8E+00	6.4E+02	6.1E+02	3.4E+03	5.2E+03	2.6E+03	5.2E+03	1.2E+04	4.9E+03	2.2E+04		4.6E+03	4.9E+03	4.9E+03
Anode I	PA3	4.2E-01	1.0E-01	4.4E-03	5.8E-01	5.5E-01	3.1E+00	4.7E+00	2.3E+00	4.7E+00	1.1E+01	4.4E+00	2.0E+01		4.2E+00	4.4E+00	4.4E+00
Anode I	PA4	4.8E+01	1.1E+01	5.0E-01	6.7E+01	6.3E+01	3.5E+02	5.4E+02	2.7E+02	5.4E+02	1.3E+03	5.1E+02	2.3E+03		4.8E+02	5.1E+02	5.1E+02
Anode I	PA5	2.9E+02	7.0E+01	3.0E+00	4.1E+02	3.9E+02	2.1E+03	3.3E+03	1.6E+03	3.3E+03	7.8E+03	3.1E+03	1.4E+04		2.9E+03	3.1E+03	3.1E+03
Anode I	PA6	1,0E+03	2,5E+02	1,1E+01	1,5E+03	1,4E+03	7,6E+03	1,2E+04	5,8E+03	1,2E+04	2,8E+04	1,1E+04	5,0E+04		1,0E+04	1,1E+04	1,1E+04
Anode I	PA6	2.8E+03	6.7E+02	2.9E+01	3.9E+03	3.7E+03	2.1E+04	3.2E+04	1.6E+04	3.2E+04	7.5E+04	3.0E+04	1.3E+05		2.8E+04	3.0E+04	3.0E+04
Anode I	PA7	4.3E+01	1.0E+01	4.5E-01	6.0E+01	5.7E+01	3.1E+02	4.8E+02	2.4E+02	4.8E+02	1.1E+03	4.6E+02	2.0E+03		4.3E+02	4.6E+02	4.6E+02
Anode I	PA8	1.0E+01	2.5E+00	1.1E-01	1.5E+01	1.4E+01	7.6E+01	1.2E+02	5.8E+01	1.2E+02	2.8E+02	1.1E+02	5.0E+02		1.0E+02	1.1E+02	1.1E+02
Anode I	PA9	2.4E+04	5.8E+03	2.6E+02	3.4E+04	3.2E+04	1.8E+05	2.8E+05	1.4E+05	2.8E+05	6.5E+05	2.6E+05	1.2E+06		2.4E+05	2.6E+05	2.6E+05
Anode I	PA10	2.7E+02	6.5E+01	2.8E+00	3.8E+02	3.6E+02	2.0E+03	3.1E+03	1.5E+03	3.1E+03	7.2E+03	2.9E+03	1.3E+04		2.7E+03	2.9E+03	2.9E+03
Anode I	PA11	1.0E+03	2.5E+02	1.1E+01	1.4E+03	1.4E+03	7.6E+03	1.2E+04	5.8E+03	1.2E+04	2.8E+04	1.1E+04	5.0E+04		1.0E+04	1.1E+04	1.1E+04
Anode I	PA12	2.9E+01	7.0E+00	3.1E-01	4.1E+01	3.9E+01	2.1E+02	3.3E+02	1.6E+02	3.3E+02	7.8E+02	3.1E+02	1.4E+03		2.9E+02	3.1E+02	3.1E+02
Anode I	PA13	3.7E+03	9.0E+02	3.9E+01	5.2E+03	5.0E+03	2.7E+04	4.2E+04	2.1E+04	4.2E+04	1.0E+05	4.0E+04	1.8E+05		3.7E+04	4.0E+04	4.0E+04
Anode I	PA14	2.8E+03	6.7E+02	2.9E+01	3.9E+03	3.7E+03	2.1E+04	3.2E+04	1.6E+04	3.2E+04	7.5E+04	3.0E+04	1.3E+05		2.8E+04	3.0E+04	3.0E+04
Anode I	PA15	1.2E+00	3.0E-01	1.3E-02	1.7E+00	1.7E+00	9.2E+00	1.4E+01	7.0E+00	1.4E+01	3.3E+01	1.3E+01	6.0E+01		1.2E+01	1.3E+01	1.3E+01
Anode I	A1	1.5E+04	3.7E+03	1.6E+02	2.1E+04	2.0E+04	1.1E+05	1.7E+05	8.5E+04	1.7E+05	4.1E+05	1.6E+05	7.3E+05		1.5E+05	1.6E+05	1.6E+05

Table 3.14 Local concentrations in agricultural soil and grassland (µg.kg$_{wwt}^{-1}$) for the ferro-alloy and graphite production industry.

	agricultural soil		grassland	
Substance/Scenario	**Ferro-Alloy**	**Graphite**	**Ferro-Alloy**	**Graphite**
Naphthalene	0.9	1.1	1.4	1.8
Acenaphthene	0.2	0.6	0.4	1.1
Acenaphthylene	0.5	0.3	0.9	0.6
Fluorene	2.1	0.7	4.0	1.3
Anthracene	1.0	0.6	2.0	1.2
Phenanthrene	6.2	8.3	12.5	16.9
Fluoranthene	10.3	15.6	20.8	31.2
Pyrene	4.9	7.8	9.9	15.6
Benzo(a)anthracene	6.6	7.2	13.0	14.3
Chrysene	14.3	23.4	27.3	48.1
Benzo(a)pyrene	11.8	2.6	23.4	5.3
Benzo(b)fluoranthene	23.4	14.3	46.8	29.9
Benzo(k)fluoranthene	-	18.6	-	28.6
Benzo(ghi)perylene	6.8	3.0	13.0	6.0
Dibenzo(a,h)anthracene	3.3	1.8	6.4	3.5
Indeno(1,2,3-cd)pyrene	7.2	3.8	14.3	7.7

Ferro-alloy: Ferro-alloy production (including paste preparation);
Graphite: production of graphite electrodes (including paste preparation) using dry scrubbers;
NA: no information available

Comparison with measured data

Production

In the absence of local monitoring data, no comparison between the predicted and measured levels can be made. Though, for all sites the predicted concentrations for all 16 EPA PAHs were within the range of the background concentrations reported for arable – and grassland and below those measured in urban areas. The highest concentrations were predicted for site 1 and 3, especially for the PAHs Phenanthrene, fluoranthene, pyrene, Benzo[bjk]fluoranthene and Indeno(1,2,3-cd)pyrene.

Industrial use

The Clocal concentrations for anode and VSS production plants are within the range of urban areas reported by Wilcke (2000) or higher. For ferro-alloy plants the local concentrations are comparable to those given for arable- and grassland. The local concentrations for plants using prebaked anodes were negligible in comparison to background concentrations. As no monitoring data has been provided by the industry, no comparison for the local environmental concentrations can be made.

Atmosphere
The local concentrations of the EPA 16 PAHs in the atmosphere have been calculated in according to the Technical Guidance Document (EC, 2003). The concentrations in air near the production sites and sites near pitch processing plants uses presented in Table 3.15, Table 3.16 and Table 3.17 do not include the regional background concentration.

The local air compartment receives its input from direct emissions to air, and volatilisation from the sewage treatment plant. The concentration in air at a distance of 100 meters from the point source is estimated with a Gaussian plume model. Degradation and wet and dry deposition of both vapour and aerosol particles are taken into account as the most important fate processes.

Production

Local concentrations 100 m from the point source are presented in the following table. Atmospheric release from the waste water treatment plant does not contribute to the local concentration for those sites with reported on-site waste water treatment; either biological or physical (site 4, 6, 8 and 9). This is caused by the facts that in these cases the direct emissions to water are used as input and the STP calculation procedure is not used in the local assessment. In general it can be stated that for CTPHT production sites the contribution from the waste water treatment is not significant with respect to the local air emissions from the production process.

Table 3.15 Local concentrations in air at 100 m from the point source (ng.m^{-3}) at the production sites.

Substance/Site	1	3	4	5	6	7	8	9
Naphthalene	190	1900	900	860	110	42	120	120
Acenaphthene	13	56	20	130	12	4.8	14.0	13.0
Acenaphthylene	57	42	15	45	31	12.0	35	34
Fluorene	12	38	11	260	6.2	2.50	7.1	6.8
Anthracene	10	20.0	3.9	140	5.4	2.1	6.1	6.0
Phenanthrene	29	120	14	870	16	6.3	18.0	18.0
Fluoranthene	20	47	7.8	290	11	4.3	12.0	12.0
Pyrene	17	29	5.6	59	9.1	3.8	10.00	10.0
Benzo(a)anthracene	5.1	4.5	1.4	9.4	2.9	1.10	3.0	3.0
Chrysene	4.5	7.2	1.2	14	2.4	0.98	2.8	2.70
Benzo(a)pyrene	7.7	5.5	2.0	4.9	4.1	1.60	6.1	4.6
Benzo(b)fluoranthene	63	42	16	4.6	34	14.0	39	38
Benzo(k)fluoranthene	12	10.0	3.2	7.0	6.5	2.50	7.6	3.3
Benzo(ghi)perylene	2.7	2.1	0.66	3.5	1.4	0.55	1.6	1.50
Dibenzo(a,h)anthracene	10	6.7	2.4	4.4	5.2	2.10	7.1	5.7
Indeno(1,2,3-cd)pyrene	4.3	3.2	1.1	3.5	2.3	0.91	4.1	2.50

Industrial/professional use

Local concentrations 100 m from the point source are presented in the following table. Atmospheric release from the waste water treatment plant does not contribute to the local concentration because it was assumed that the wet scrubber effluent and cooling water effluent is not treated in the local STP.

The calculations in EUSES 2.0.3 are based on an included OPS (Operational priority substances) model assuming 100 metres from one point source at an emission height of 10 m. According to EAA, a more realistic assumption for the aluminium smelters would be an emission from multiple sources at a height higher than 10 m. This has been modelled by NILU for two Norwegian aluminium smelters, where it is shown that the atmospheric fluor and PAH concentrations are significantly lower than those calculated with EUSES 2.0.3. Therefore for the VSS plants the air concentration has been adjusted using OPS-Pro 4.1 based on a higher emission height (25 m) and a larger emission surface (500 by 500 m).

Table 3.16 Local concentrations in air, at 100 m from point source (ng.m^{-3}) for ferro-alloy and graphite production industry.

Substance/Scenario	Ferro-Alloy	Graphite
Naphthalene	820	970
Acenaphthene	140	360
Acenaphthylene	310	210
Fluorene	420	140
Anthracene	190	120
Phenanthrene	1200	1700
Fluoranthene	750	1100
Pyrene	400	630
Benzo(a)anthracene	75	81
Chrysene	130	220
Benzo(a)pyrene	56	13
Benzo(b)fluoranthene	180	110
Benzo(k)fluoranthene		58
Benzo(ghi)perylene	25	11
Dibenzo(a,h)anthracene	11	6.1
Indeno(1,2,3-cd)pyrene	25	13

Ferro-alloy: Ferro-alloy production (including paste preparation);
Graphite: production of graphite electrodes (including paste preparation) using dry scrubbers

Table 3.17 Local concentrations in air (ng.m^{-3}) for the primary aluminium production and anode baking facilities.

Use cat.	Site	Naphthalene	Acenaphthene	Acenaphthylene	Fluorene	Anthracene	Phenanthrene	Fluoranthene	Pyrene	Benz(a)anthracene	Chrysene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(k)fluoranthene	Benzo(ghi)perylene	Dibenzo(a,h)anthracene	Indeno(1,2,3-cd)pyrene
VSS II	S1	5.6E+02	8.9E+01	2.2E+02	2.7E+02	8.0E+01	7.3E+02	4.0E+02	2.1E+02	3.8E+01	7.3E+01	3.6E+01	1.1E+02		1.7E+01	6.9E+00	1.7E+01
VSS II	S3	1.4E+03	2.3E+02	5.6E+02	6.9E+02	2.1E+02	1.9E+03	1.0E+03	5.3E+02	9.8E+01	1.9E+02	9.2E+01	2.8E+02		4.4E+01	1.8E+01	4.4E+01
VSS II	S4	1.5E+03	2.4E+02	6.0E+02	7.3E+02	2.2E+02	2.0E+03	1.1E+03	5.7E+02	1.0E+02	2.0E+02	9.8E+01	2.9E+02		4.7E+01	1.9E+01	4.7E+01
SWPB	P7	8.7E-03		2.6E+00	5.9E-01			5.0E+01	2.1E+01	6.3E+00	8.7E+00	2.9E+00	2.9E+00	2.9E+00	1.4E+00	5.9E-01	8.7E-01
VSS I	S5	1.6E+03	2.6E+02	6.4E+02	7.6E+02	1.6E+02	8.3E+02	4.6E+02	3.5E+02	1.0E+02	1.9E+02	1.0E+02	4.1E+02		5.9E+01	1.0E+01	4.9E+01
VSS I	S6	1.6E+03	2.5E+02	6.1E+02	7.3E+02	1.5E+02	8.1E+02	4.4E+02	3.3E+02	9.8E+01	1.9E+02	9.8E+01	4.0E+02		5.7E+01	9.8E+00	4.8E+01
Anode I	PA1	6.1E+02	8.3E+01	4.0E+00	1.6E+02	1.4E+02	8.3E+02	4.3E+02	2.4E+02	7.2E+01	1.3E+02	2.7E+01	1.9E+02		2.1E+01	2.1E+01	2.1E+01
Anode I	PA2	2.6E+02	3.5E+01	1.7E+00	6.8E+01	6.1E+01	3.5E+02	1.8E+02	1.0E+02	3.1E+01	5.6E+01	1.1E+01	8.2E+01		8.7E+00	8.7E+00	8.7E+00
Anode I	PA3	2.3E-01	3.2E-02	1.5E-03	6.2E-02	5.5E-02	3.2E-01	1.7E-01	9.4E-02	2.8E-02	5.1E-02	1.0E-02	7.5E-02		7.9E-03	7.9E-03	7.9E-03
Anode I	PA4	2.7E+01	3.6E+00	1.8E-01	7.1E+00	6.3E+00	3.7E+01	1.9E+01	1.1E+01	3.2E+00	5.9E+00	1.2E+00	8.5E+00		9.0E-01	9.0E-01	9.0E-01
Anode I	PA5	1.6E+02	2.2E+01	1.1E+00	4.3E+01	3.9E+01	2.2E+02	1.2E+02	6.6E+01	1.9E+01	3.6E+01	7.3E+00	5.2E+01		5.5E+00	5.5E+00	5.5E+00
Anode I	PA6	5.8E+02	8.0E+01	3.8E+00	1.5E+02	1.4E+02	8.0E+02	4.1E+02	2.3E+02	6.9E+01	1.3E+02	2.6E+01	1.9E+02		2.0E+01	2.0E+01	2.0E+01
Anode I	PA6	1.6E+03	2.2E+02	1.0E+01	4.2E+02	3.7E+02	2.2E+03	1.1E+03	6.3E+02	1.9E+02	3.5E+02	7.0E+01	5.0E+02		5.3E+01	5.3E+01	5.3E+01
Anode I	PA7	2.4E+01	3.3E+00	1.6E-01	6.3E+00	5.7E+00	3.3E+01	1.7E+01	9.6E+00	2.8E+00	5.3E+00	1.1E+00	7.7E+00		8.1E-01	8.1E-01	8.1E-01
Anode I	PA8	5.9E+00	8.0E-01	3.8E-02	1.5E+00	1.4E+00	8.0E+00	4.2E+00	2.3E+00	6.9E-01	1.3E+00	2.6E-01	1.9E+00		2.0E-01	2.0E-01	2.0E-01
Anode I	PA9	1.4E+04	1.9E+03	9.0E+01	3.6E+03	3.2E+03	1.9E+04	9.7E+03	5.5E+03	1.6E+03	3.0E+03	6.1E+02	4.4E+03		4.6E+02	4.6E+02	4.6E+02
Anode I	PA10	1.5E+02	2.1E+01	1.0E+00	4.0E+01	3.6E+01	2.1E+02	1.1E+02	6.1E+01	1.8E+01	3.3E+01	6.8E+00	4.9E+01		5.1E+00	5.1E+00	5.1E+00
Anode I	PA11	5.8E+02	7.9E+01	3.8E+00	1.5E+02	1.4E+02	8.0E+02	4.1E+02	2.3E+02	6.9E+01	1.3E+02	2.6E+01	1.9E+02		2.0E+01	2.0E+01	2.0E+01
Anode I	PA12	1.6E+01	2.2E+00	1.1E-01	4.3E+00	3.9E+00	2.2E+01	1.2E+01	6.6E+00	1.9E+00	3.6E+00	7.3E-01	5.2E+00		5.5E-01	5.5E-01	5.5E-01
Anode I	PA13	2.1E+03	2.9E+02	1.4E+01	5.6E+02	5.0E+02	2.9E+03	1.5E+03	8.4E+02	2.5E+02	4.6E+02	9.4E+01	6.7E+02		7.1E+01	7.1E+01	7.1E+01
Anode I	PA14	1.6E+03	2.2E+02	1.0E+01	4.2E+02	3.7E+02	2.2E+03	1.1E+03	6.3E+02	1.9E+02	3.5E+02	7.0E+01	5.0E+02		5.3E+01	5.3E+01	5.3E+01
Anode I	PA15	7.0E-01	9.6E-02	4.6E-03	1.9E-01	1.7E-01	9.6E-01	5.0E-01	2.8E-01	8.3E-02	1.5E-01	3.1E-02	2.2E-01		2.4E-02	2.4E-02	2.4E-02
Anode I	A1	8.6E+03	1.2E+03	5.6E+01	2.3E+03	2.0E+03	1.2E+04	6.1E+03	3.4E+03	1.0E+03	1.9E+03	3.8E+02	2.7E+03		2.9E+02	2.9E+02	2.9E+02

Comparison with measured data

Production

The calculated air concentrations near all production sites are all close to the upper range or higher than those measured in urban areas. Though most of PAHs concentrations were within the range reported for industrial areas. Only the concentration predicted for site 5 were higher.

Industrial use

The data obtained by Hagen (2002) showed that the B(a)P concentrations in air in the vicinity of plants using Søderberg technology are between 0.1 and 10 ng/m^3. The calculated concentration for the plants using this technology are between 30 and 100 ng/m^3, which is one to two orders of magnitude higher. For the plant located a Karmøy (site S3), where the measured and predicted concentrations are related to the same distance (i.e. 100 m distance), the predicted air concentrations seem to be two orders of magnitude higher. For other plants the concentration measured at 1 km distance. When it is assumed that roughly the concentration at 100 m are 10 times higher than at 1 km, the concentrations for the other sites shown in Table 3.64 seems to deviate to much lesser extent from the predicted concentrations than for Karmøy.

For site PA2 (Sunndalsøra), more recent data shows that the concentration B(a)P at 500 m distance from the plant is a factor of 70 lower than estimated at 100 m distance (0.16 ng/m^3 versus 11 ng/m^3). For site S4 recent measurements indicate that the B(a)P concentration at 200 m distance were a factor of 40 lower than estimated (2.5 ng/m^3 versus 98 ng/m^3). It is unknown to which extent the actual concentrations for the other PAHs deviate from those predicted.

For site PA7, measured HF data at a point 100m from the plant is 0.5 µg HF/m3. The corresponding modelled value is 9.4µg/m3.

Overall, the measured data shows that the modelled air concentration can be considered as a conservative prediction.. However, a more accurate measure of air concentration can only be obtained by local measurements at a relevant distance and direction from the emission source.

STP

Some CTPHT production plants discharge their waste water to a municipal STP or off-site biological waste water treatment plant. For these sites the sewage treatment model has been applied to calculate the fate in the STP. The emission from the production site and the effluent flow rate of the external waste water treatment facility are required as input. The model calculates the emission from the sewage treatment plant to air, the concentration in sewage sludge and the concentration in the effluent. A detailed description of the STP model is given in the Technical Guidance Document (EC, 2003). The highest PEC for total PAH in the effluent which is considered relevant for the risk assessment is 114 µg/l at site 4. The concentrations in the effluent of the other production sites were ≤ 2 µg/l (Table 3.18).

Table 3.18 Concentrations STP effluent (ng.l^{-1}) for the relevant production sites.

Substance/Site	1 1)	3 1)	4 2)	5 1)	6 2)	7 1)	8 3)	9 3)
Naphthalene	0.73	73	750	60	74	1.3	n.r.	n.r.
Acenaphthene	0.14	48	433	20	38	0.3	n.r.	n.r.
Acenaphthylene	n.d.	92	1783	105	5	0.4	n.r.	n.r.
Fluorene	0.094	152	435	20	21.5	0.6	n.r.	n.r.
Anthracene	0.018	37	867	24	24.5	0.2	n.r.	n.r.
Phenanthrene	0.17	88	1267	0.46	65.5	2.5	n.r.	n.r.
Fluoranthene	0.06	91	6592	8.0	61.5	0.9	n.r.	n.r.
Pyrene	0.33	73	4842	6.9	36.5	0.9	n.r.	n.r.
Benzo(a)anthracene	0.0067	30	5075	1.2	8.5	0.3	n.r.	n.r.
Chrysene	0.0070	31	4433	0.15 4)	8	0.3	n.r.	n.r.
Benzo(a)pyrene	0.0064	13	19608	0.14 4)	10	0.2	n.r.	n.r.
Benzo(b)fluoranthene	0.0064	156	29333	0.14 4)	7.5	0.4	n.r.	n.r.
Benzo(k)fluoranthene	0.0064	52	9533	0.14 4)	6.5	0.1	n.r.	n.r.
Benzo(ghi)perylene	0.0063	64	11992	0.14 4)	5	0.2	n.r.	n.r.
Dibenzo(a,h)anthracene	0.0060	17	3325	0.13 4)	6	0.1	n.r.	n.r.
Indeno(1,2,3-cd)pyrene	0.0060	73	13350	0.13 4)	5.5	0.2	n.r.	n.r.

1) discharged from these sites is directed to off-site (public) sewage treatment plants. Sludge from these STPs goes to agricultural soil. These effluent concentrations have been calculated applying the STP model in EUSES (EC, 2003); 2) on-site waste water treatment, reported effluent concentration; 3) these sites have no on-site biological (activated sludge) wastewater treatment theefore the table does not give effluent data for these sites, indicated with n.r. ; 4) detection limit is 0.01 µg/l,

3.2 EFFECTS ASSESSMENT

In the effect assessment the ecotoxicity data has been evaluated for the 16 EPA PAHs separately and subsequently PNEC for the individual PAHs will be derived (see Table 3.19, Table 3.20 and Table 3.21). The data from both literature and other EU RARs are used.

PAHs can be toxic via different mode of actions, such as non-polar narcosis and phototoxicity. The phototoxic effects can be observed after a short period of exposure, which explains why for PAHs like anthracene, fluoranthene and pyrene, where photoxicity is most evident, the acute toxicity values are even lower than the chronic toxicity values.

Although it is recognized that at present time, the ability to conduct PAH-photoactivated risk assessment of acceptable uncertainty is limited by comprehensive information on species exposure to PAH and UV radiation during all life stages, it is thought that the phototoxic effects can not be ignored in the present risk assessment. Therefore these effects are also considered in deriving the PNECs for aquatic species. It should be noted that the UV exposure levels of the selected studies did not exceed the UV levels under natural sun light conditions.

In the table below the derived PNECs for the different compartments are presented.

Aquatic compartment (incl. sediment)

Table 3.19. The PNEC for the various PAHs for fresh and marine water organisms

Compound	PNEC fresh water (µg/l)	AF	Species	PNEC marine water (µg/l)	AF	species
Naphthalene	2	10	*Oncorhynchus mykiss*	2	10	*O. mykiss*
Anthracene	0.1	10	*Daphnia pulex acute*	0.1	10	*D. pulex acute*
Phenanthrene	1.3	10	*Ceriodaphnia dubia*	1.3	10	*C. dubia*
Fluoranthene	0.01	10	*Pleuronectes americanus acute*	0.01	10	*P. americanus acute*
Pyrene	0.023	10	*Mulinea lateralis acute*	0.023	10	*M. lateralis acute*
9H-Fluorene	2.5	10	*C. dubia*	0.25	100	*C. dubia*
Acenaphthylene	1.3	50	*C. dubia*	0.13	500	*C. dubia*
Acenaphthene	3.8	10	*Pseudokirchneriella subcapitata*	0.38	100	*P. subcapitata*
Chrysene	0.07	10	*D. magna acute*	0.007	100	*D. magna acute*
Benzo(a)anthracene	0.012	100	*P. subcapitata*	0.0012	1000	*P. subcapitata*
Benzo(b)fluoranthene	0.017	*	*Brachydanio rerio*	0.0017	100	*B. rerio*
Benzo(ghi)perylene	0.0082	10	*C. dubia*	0.00082	100	*C. dubia*
Benzo(k)fluoranthene	0.017	10	*Brachydanio rerio*	0.0017	100	*B. rerio*
Benzo(a)pyrene	0.022	10	*Crassostrea gigas*	0.022	10	*C. gigas*
Dibenzo(a,h)anthracene	0.0014	100	*P. subcapitata*	0.00014	1000	*P. subcapitata*
Indeno[123*cd*]pyrene	0.0027	100	*C. dubia*	0.00027	1000	*C. dubia*

* For benzo(b)fluoranthene the PNEC is the same as for benzo(k)fluoranthene after read-across with this compound

Table 3.20. The PNEC for the various PAHs for fresh and marine sediment organisms

Compound	PNEC fresh water sediment (mg/kg_{dw})	AF	Species	PNEC marine sediment (mg/kg_{dw})	AF	species
Naphthalene	2.9	1000 vs. EqP	*R. abronius*	0.29	10000 vs. EqP	*R. abronius*
Anthracene	0.14	100	*C. riparius*	0.014	1000	*C. riparius*
Phenanthrene	5	10	*H. azteca/ C. riparius*	5	10	*H. azteca/ C. riparius*
Fluoranthene	0.96	10	*C. riparius*	0.96	10	*C. riparius*
Pyrene	2.8	50	*R. abronius*	1.4	100	*R. abronius*
9H-Fluorene	2,56	EqP		0.26	EqP	
Acenaphthylene	0.34	EqP		0.03	EqP	
Acenaphthene	1.6	100	*R. abronius*	0.16	1000	*R. abronius*
Chrysene	2.79	EqP		0.28	EqP	
Benzo(a)anthracene	0.60	EqP		0.06	EqP	
Benzo(b)fluoranthene	1.38	EqP		0.14	EqP	
Benzo(ghi)perylene	0.84	EqP		0.084	EqP	
Benzo(k)fluoranthene	1.38	EqP		0.14	EqP	
Benzo(a)pyrene	1.83	EqP		1.83	EqP	
Dibenzo(a,h)anthracene	0.27	EqP		0.027	EqP	
Indeno[123*cd*]pyrene	0.63	EqP		0.063	EqP	

Terrestrial compartment

Table 3.21. The PNEC for the various PAHs for soil organisms

Compound	PNEC soil (mg/kg_{dw})	AF	species
Naphthalene	1.0	10	*Folsomia* candida
Anthracene	0.13	50	*F. fimetaria*
Phenanthrene	1.8	10	*F. fimetaria*
Fluoranthene	1.5	10	Nitrification
Pyrene	1.0	10	*F. candida*
9H-Fluorene	1.0	10	*F. fimetaria*
Acenaphthylene	0.29	100	*F. fimetaria*
Acenaphthene	0.038	50	*Lactuca sativa*
Chrysene	0.55	EqP	
Benzo(a)anthracene	0.079	10	*Oniscus asellus*
Benzo(b)fluoranthene	0.28	EqP	
Benzo(ghi)perylene	0.17	EqP	
Benzo(k)fluoranthene	0.27	EqP	
Benzo(a)pyrene	0.053	10	*Porcellio scaber*
Dibenzo(a,h)anthracene	0.054	EqP	
Indeno[123*cd*]pyrene	0.13	EqP	

Atmosphere

No data available and no $PNEC_{air}$ can be derived.

Sewage treatment plant

The toxicity of CTPHT (electrode binder BX 90) to *Pseudomonas putida* has been tested in a cell multiplication inhibition test according to a draft guideline DIN 38412; 1989 (Hillman, 1991). Over the whole test range (625 to 10000 mg CTPHT /l) no inhibition was observed. In an addition test in the same study, CTPHT (24 mg) was dissolved in the highest permissible concentration of a solubilizer toluol (0.1 g/l). From this solution 5 test concentration from 1.5 to 20 mg/l were prepared. Within this test range no inhibition was observed. No analysis of the test solution was performed.

Although this study is sufficient for the base set of CTPHT, it does not provide data to derive exact $PNEC_{microorganisms}$ values for the individual PAHs in a STP. Based on the solubility data given in section 1.2, it can however be assumed that the PNEC values will be in the range of µg/l or higher.
An additional study is available in which creosote was tested for toxicity towards activated sludge according to OECD 209 (Lebertz, 1984). The EC50 was determined at 670 mg/l, which suggest that the EC50 values for the individual PAHs are not below the µg/l range. Although toxicity data on *Vibrio fischeri* cannot be used for the risk assessment of a STP, supporting evidence for the last conclusion is found in toxicity studies with this species for the different PAHs (Loibner et al., 2004). The EC10 values for the two and three ring PAHs range from 0.13 mg/l for phenanthrene to 0.39 mg/l for naphthalene. For PAHs with four rings or more no toxicity is observed up to the saturated aqueous solution. It was argued that the toxicity of PAHs towards V. *fischeri* seems therefore to be related to the maximum water solubility rather than the toxicity of the individual PAH.

Secondary poisoning

Based on the available information PNEC oral values for the individual PAHs can not be derived.

3.3 RISK CHARACTERISATION

Considering that a range of PAHs are emitted simultaneously, it is obvious to assess the risk for the mixture of PAHs and not for the PAHs individually. A common method to determine the toxicity of a mixture is the toxic unit concept. A toxic unit (TU) is defined as the ratio of the concentration in a medium to the effect concentration in that medium. The toxicity of the mixture is the sum of the individuals TUs. Use of the toxic unit concept requires that the dose-response relationships of the individual compounds have similar shapes, which in general holds for compounds with the same mode of action. The additivity of the toxicity of narcotic chemicals has been demonstrated by a number of investigators and is also considered applicable for PAHs (DiToro *et al.*, 2000; DiToro & McGrath, 2000). As shown in section 3.2, the most sensitive endpoints were not for all PAHs based on the same mode of action. For a limited number of PAHs (anthracene, fluoranthene, pyrene and chrysene) the lowest toxicity is based on phototoxicity and not non-polar narcosis. However, the difference in toxicity is overall small and limited to the aquatic compartment. Therefore, the TU approach is considered feasible for the sum of the 16 EPA PAHs.

For the risk assessment of CTPHT the TU is expressed as a ratio of the Clocal to the PNEC for each PAH. The toxicity of the combination of PAHs is assessed by adding all the risk quotients (Clocal/PNEC) together. The exposure to the mixture is considered as a risk in case the sum is higher than 1.

Since many unintentional sources contribute to the total emission of PAHs into the environment (see section 3.1.2.), which by extension are not related to production and use of CTPHT , the risk characterisation will only be focussed on the PAHs emitted by producers and downstream users of CTPHT on a local scale. To put the risk ratio's derived for the local scale into perspective risk ratio's for the regional background are calculated using monitoring data available for fresh water environment (COMMPS database), the marine environment (OSPAR BRCs) and soil (peer review of Wilcke) and the PNEC determined for the 16 EPA PAHs. No formal conclusions are derived for the regional background.

3.3.1 Aquatic compartment (incl. sediment)

In Table 3.22 and Table 3.23 the risk characterisation (RC) for surface water and sediment is presented for the CTPHT production. For the industrial use the RC is listed in Table 3.24, Table 3.25 and Table 3.26.

In accordance to the EU TGD, for all PAHs with a log Kow > 5 an additional factor of 10 is applied to the $PNEC_{sediment}$ in case no experimental data are available and therefore the equilibrium partitioning approach is used.

3.3.1.1 Production

Table 3.22 Clocal/PNEC for surface water and marine water (*) for the different CTPHT production sites.

Substance/Site	1	3*	4	5	6	7	8	9
Naphthalene	0.0	0.0	0.0	0.001	0.0	0.0	0.0	0.0
Acenaphthene	0.0	0.0	0.0	0.000	0.0	0.0	0.0	0.0
Acenaphthylene	n.d.	0.0	0.0	0.003	0.0	0.0	0.0	0.0
Fluorene	0.0	0.0	0.0	0.000	0.0	0.0	0.0	0.0
Anthracene	0.0	0.0	0.0	0.008	0.0	0.0	0.0	0.0
Phenanthrene	0.0	0.0	0.0	0.000	0.0	0.0	0.0	0.0
Fluoranthene	0.0	0.0	0.5	0.025	0.0	0.0	0.0	0.0
Pyrene	0.0	0.0	0.2	0.010	0.0	0.0	0.0	0.0
Benzo(a)anthracene	0.0	0.0	0.22	0.002	0.0	0.0	0.0	0.0
Chrysene	0.0	0.0	0.0	0.000	0.0	0.0	0.0	0.0
Benzo(a)pyrene	0.0	0.0	0.3	0.000	0.0	0.0	0.0	0.0
Benzo(b)fluoranthene	0.0	0.0	0.7	0.000	0.0	0.0	0.0	0.0
Benzo(k)fluoranthene	0.0	0.0	0.2	0.000	0.0	0.0	0.0	0.0
Benzo(ghi)perylene	0.0	0.0	0.5	0.000	0.0	0.0	0.0	0.1
Dibenzo[a.h]anthracene	0.0	0.0	0.5	0.001	0.0	0.0	0.0	0.4
Indeno[1.2.3-cd]pyrene	0.0	0.0	1.0	0.000	0.0	0.0	0.0	0.2
Sum PAH	**0.0**	**0.0**	**4**	**0.05**	**0.1**	**0.01**	**0.1**	**0.9**

Table 3.23 Clocal/PNEC for sediment for the different CTPHT production sites.

Substance/Site	1	3	4	5	6	7	8	9
Naphthalene	0.0	0.0	0.0	0.00	0.0	0.00	0.0	0.0
Acenaphthene	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.0
Acenaphthylene	0.0	0.0	0.0	0.01	0.0	0.00	0.0	0.0
Fluorene	0.0	0.0	0.0	0.00	0.0	0.00	0.0	0.0
Anthracene	0.0	0.1	0.0	0.05	0.0	0.00	0.0	0.0
Phenanthrene	0.0	0.0	0.0	0.00	0.0	0.00	0.0	0.0
Fluoranthene	0.0	0.0	0.1	0.01	0.0	0.00	0.0	0.0
Pyrene	0.0	0.0	0.0	0.00	0.0	0.00	0.0	0.0
Benzo(a)anthracene	0.0	0.0	2.5	0.06	0.0	0.00	0.1	0.5
Chrysene	0.0	0.0	0.4	0.00	0.0	0.00	0.0	0.1
Benzo(a)pyrene	0.0	0.0	4.0	0.00	0.0	0.00	0.0	0.4
Benzo(b)fluoranthene	0.0	0.0	8.0	0.00	0.0	0.00	0.0	0.3
Benzo(k)fluoranthene	0.0	0.0	2.5	0.00	0.0	0.00	0.0	0.3
Benzo(ghi)perylene	0.0	0.0	6.0	0.01	0.0	0.00	0.0	1.0

Substance/Site	**1**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Dibenzo[a.h]anthracene	0.0	0.0	6.1	0.02	0.1	0.00	0.1	3.7
Indeno[1.2.3-cd]pyrene	0.0	0.0	10.9	0.01	0.0	0.01	0.0	1.7
Sum PAH	**0.0**	**0.0**	**41**	**0.2**	**0.3**	**0.02**	**0.3**	**8**

3.3.1.2 Industrial use/processing

Table 3.24 Clocal/PNEC for water and sediment for the ferro-alloy industry.

Substance	**Sea water**	**Marine sediment**
Naphthalene	0.00028	0.00025
Acenaphthene	0.0072	0.010
Acenaphthylene	0.0084	0.0084
Fluorene	0.0064	0.0065
Anthracene	0.033	0.71
Phenanthrene	0.014	0.0084
Fluoranthene	2.8	0.28
Pyrene	0.75	0.077
Benzo(a)anthracene	2.3	23
Chrysene	0.85	8.5
Benzo(a)pyrene	0.043	0.43
Benzo(b)fluoranthene	1.1	11
Benzo(k)fluoranthene	NA	NA
Benzo(ghi)perylene	0.49	4.9
Dibenzo(a,h)anthracene	0.81	8.1
Indeno(1,2,3-cd)pyrene	0.85	8.4
Sum of PAH	**10**	**69**

Ferro-alloy: Ferro-alloy production (including paste preparation)

Table 3.25 CLocal/PNEC in water (marine and fresh) for primary aluminium production and anode baking.

Use cat.	Site	Naphthalene	Acenaphthene	Acenaphthylene	Fluorene	Anthracene	Phenanthrene	Fluoranthene	Pyrene	Benz(a)anthracene	Chrysene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(ghi)perylene	Dibenzo(a,h)anthracene	Indeno(1,2,3-cd)pyrene	Total Clocal/PNEC
VSS II	S1	2.9E-03	6.4E-02	4.4E-02	6.2E-02	2.1E-01	1.4E-01	2.6E+01	7.1E+00	2.3E+01	7.7E+00	3.9E-01	1.5E+01	4.6E+00	7.3E+00	8.1E+00	100
VSS II	S3	8.5E-04	1.9E-02	1.3E-02	1.8E-02	6.0E-02	4.2E-02	7.6E+00	2.1E+00	6.8E+00	2.2E+00	1.1E-01	4.5E+00	1.4E+00	2.1E+00	2.4E+00	29
VSS II	S4	8.8E-02	2.0E+00	1.4E+00	1.9E+00	6.2E+00	4.4E+00	7.8E+02	2.2E+02	7.1E+02	2.3E+02	1.2E+01	4.6E+02	1.4E+02	2.2E+02	2.5E+02	3038
VSS I	S5	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
VSS I	S6	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Anode I	PA1 1)	5.1E-03	1.1E-01	7.9E-02	1.1E-01	3.3E+00	9.4E-01	6.9E+01	2.3E+01	6.8E+01	1.0E+01	6.9E-01	1.9E+01	4.9E+00	2.5E+01	1.1E+01	234
Anode I	PA2	8.1E-03	1.8E-01	1.2E-01	1.7E-01	5.3E+00	1.5E+00	1.1E+02	3.6E+01	1.1E+02	1.6E+01	1.1E+00	3.0E+01	7.7E+00	3.9E+01	1.7E+01	369
Anode I	PA3	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Anode I	PA4	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Anode I	PA5	3.4E-02	7.3E-02	5.2E-02	7.0E-02	2.2E+01	6.2E+00	4.6E+02	1.5E+02	4.4E+01	6.5E+00	4.5E+00	1.2E+01	3.2E+00	1.6E+01	7.2E+00	730
Anode I	PA6	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Anode I	PA7	2.3E-03	4.9E-02	3.5E-02	4.7E-02	1.5E+00	4.2E-01	3.1E+01	1.0E+01	3.0E+01	4.4E+00	3.0E-01	8.3E+00	2.2E+00	1.1E+01	4.9E+00	104
Anode I	PA8	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Anode I	PA9	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Anode I	PA10	5.5E-04	1.2E-02	8.5E-03	1.1E-02	3.6E-01	1.0E-01	7.5E+00	2.5E+00	7.3E+00	1.1E+00	7.4E-02	2.0E+00	5.3E-01	2.6E+00	1.2E+00	25
Anode I	PA11	2.0E-04	4.4E-03	3.1E-03	4.2E-03	1.3E-01	3.7E-02	2.7E+00	9.1E-01	2.7E+00	3.9E-01	2.7E-02	7.4E-01	1.9E-01	9.7E-01	4.3E-01	9
Anode I	PA12 1)	1.6E-04	3.4E-04	2.4E-04	3.3E-04	1.0E-01	2.9E-02	2.1E+00	7.1E-01	2.1E-01	3.1E-02	2.1E-02	5.8E-02	1.5E-02	7.5E-02	3.4E-02	3
Anode I	PA13	1.4E-02	3.0E-02	2.1E-02	2.8E-02	8.9E+00	2.5E+00	1.8E+02	6.1E+01	1.8E+01	2.7E+00	1.8E+00	5.0E+00	1.3E+00	6.5E+00	2.9E+00	295
Anode I	PA14	1.2E-01	2.7E-01	1.9E-01	2.5E-01	8.0E+01	2.2E+01	1.7E+03	5.5E+02	1.6E+02	2.4E+01	1.6E+01	4.5E+01	1.2E+01	5.9E+01	2.6E+01	2659
Anode I	PA15	4.0E-06	8.8E-05	6.2E-05	8.4E-05	2.6E-03	7.4E-04	5.5E-02	1.8E-02	5.3E-02	7.9E-03	5.4E-04	1.5E-02	3.9E-03	1.9E-02	8.7E-03	0.2
Anode I	A1 1)	1.6E-01	3.4E-01	2.4E-01	3.2E-01	1.0E+02	2.9E+01	2.1E+03	7.0E+02	2.1E+02	3.0E+01	2.1E+01	5.7E+01	1.5E+01	7.5E+01	3.4E+01	3386

NE: no emission to water; 1) emission to fresh water

Table 3.26 CLocal/PNEC for sediment (marine and fresh) at primary aluminium production and anode baking sites.

Use cat.	Site	Naphthalene	Acenaphthene	Acenaphthylene	Fluorene	Anthracene	Phenanthrene	Fluoranthene	Pyrene	Benz(a)anthracene	Chrysene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(ghi)perylene	Dibenzo(a,h)anthracene	Indeno(1,2,3-cd)pyrene	Total Clocal/PNEC
VSS II	S1	2.8E-03	9.5E-02	4.6E-02	6.1E-02	4.3E+00	8.5E-02	2.6E+00	6.9E-01	2.3E+01	7.7E+00	3.9E+00	1.5E+02	4.6E+01	7.3E+01	8.1E+01	395
VSS II	S3	8.1E-04	2.8E-02	1.3E-02	1.8E-02	1.3E+00	2.5E-02	7.7E-01	2.0E-01	6.8E+00	2.2E+00	1.1E+00	4.5E+01	1.3E+01	2.2E+01	2.4E+01	116
VSS II	S4	8.4E-02	2.9E+00	1.4E+00	1.9E+00	1.3E+02	2.6E+00	8.0E+01	2.1E+01	7.1E+02	2.3E+02	1.2E+02	4.6E+03	1.4E+03	2.2E+03	2.5E+03	12019
VSS I	S5	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
VSS I	S6	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Anode I	PA1 1)	4.9E-03	1.6E-01	8.1E-02	1.0E-01	7.1E+01	5.6E-01	7.0E+00	2.2E+00	6.8E+01	9.9E+00	6.9E+00	1.9E+02	4.9E+01	2.5E+02	1.1E+02	761
Anode I	PA2	7.7E-03	2.6E-01	1.3E-01	1.6E-01	1.1E+02	8.8E-01	1.1E+01	3.5E+00	1.1E+02	1.6E+01	1.1E+01	3.0E+02	7.7E+01	3.9E+02	1.7E+02	1198
Anode I	PA3	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Anode I	PA4	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Anode I	PA5	3.2E-03	1.1E-01	5.3E-02	7.0E-02	4.6E+01	3.7E+00	4.6E+01	7.3E+00	4.4E+01	6.5E+00	4.5E+01	1.2E+02	3.2E+01	1.6E+02	7.3E+01	591
Anode I	PA6	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Anode I	PA7	2.2E-03	7.3E-02	3.6E-02	4.6E-02	3.1E+01	2.5E-01	3.1E+00	9.9E-01	3.0E+01	4.4E+00	3.0E+00	8.3E+01	2.2E+01	1.1E+02	4.9E+01	337
Anode I	PA8	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Anode I	PA9	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Anode I	PA10	5.3E-04	1.8E-02	8.8E-03	1.1E-02	7.6E+00	6.0E-02	7.6E-01	2.4E-01	7.3E+00	1.1E+00	7.4E-01	2.0E+01	5.3E+00	2.7E+01	1.2E+01	82
Anode I	PA11	1.9E-04	6.5E-03	3.2E-03	4.1E-03	2.8E+00	2.2E-02	2.8E-01	8.8E-02	2.7E+00	3.9E-01	2.7E-01	7.4E+00	1.9E+00	9.8E+00	4.4E+00	30
Anode I	PA12 1)	1.5E-05	5.0E-04	2.5E-04	3.3E-04	2.2E-01	1.7E-02	2.2E-01	3.4E-02	2.1E-01	3.1E-02	2.1E-01	5.8E-01	1.5E-01	7.6E-01	3.4E-01	3
Anode I	PA13	1.3E-03	4.4E-02	2.2E-02	2.8E-02	1.9E+01	1.5E+00	1.9E+01	3.0E+00	1.8E+01	2.6E+00	1.8E+01	5.0E+01	1.3E+01	6.6E+01	2.9E+01	240
Anode I	PA14	1.2E-02	3.9E-01	1.9E-01	2.5E-01	1.7E+02	1.3E+01	1.7E+02	2.7E+01	1.6E+02	2.4E+01	1.6E+02	4.5E+02	1.2E+02	5.9E+02	2.6E+02	2155
Anode I	PA15	3.9E-06	1.3E-04	6.4E-05	8.2E-05	5.6E-02	4.4E-04	5.6E-03	1.8E-03	5.3E-02	7.8E-03	5.4E-03	1.5E-01	3.8E-02	2.0E-01	8.7E-02	0.6
Anode I	A1 1)	1.5E-02	5.0E-01	2.5E-01	3.2E-01	2.2E+02	1.7E+01	2.1E+02	3.4E+01	2.1E+02	3.0E+01	2.1E+02	5.7E+02	1.5E+02	7.6E+02	3.4E+02	2745

NE: no emission to water; 1) emission to fresh water

3.3.1.3 Regional background in fresh and marine surface water (including sediment)

Not for all 16 EPA PAHs EU fresh water monitoring data are available. The available data result in risk ratio's > 1 for fresh water and fresh water sediment. (see Table 3.27).

With respect to the marine environment OSPAR data gives information on 4 PAHs. Based on these monitoring data the risk quotients for water well below 1. However, the concentrations for benzo (b+k)fluoranthene and fluoranthene, result in risk ratio's > 1 for marine sediment organisms (see Table 3.28).

Table 3.27 Ratio between the COMMPS monitoring data and PNEC for surfacewater.and sediment organisms

Compound	Surface water		Sediment	
	Median	90-percentile	Median	90-percentile
Naphthalene	0.03	0.84	0.05	0.67
Acenaphthene	0.00	0.11	0.03	0.42
Acenaphthylene			0.34	3.33
Fluorene			0.09	0.29
Anthracene	0.04	0.83	1.24	3.35
Phenanthrene			0.12	0.68
Fluoranthene	1.60	8.23	6.0	26.7
Pyrene			0.20	1.13
Benzo(a)anthracene	1.76	6.93	5.0	22.7
Chrysene			1.8	14.7
Benzo(a)pyrene	0.32	1.24	1.7	5.3
Benzo(b)fluoranthene	0.52	2.85	2.5	10.0
Benzo(k)fluoranthene	0.26	1.46	1.4	4.8
Benzo(ghi)perylene	0.98	5.73	3.5	11.9
Indeno(1,2,3-cd)pyrene	12.41	34.67	4.9	20.6
Total	17.9	62.9	28.9	126.6

Table 3.28 Ratio between the OSPAR monitoring data and PNEC for marine water and sediment organisms.

PAH	northern North Sea/ Skagerrak		southern North Sea		Arctic Ocean/ Iceland Sea	
	water	sediment	water	sediment	water	sediment
Benzo(a)pyrene	0.00	0.05 – 0.61	0.00	0.00 – 0.28	0.00	0.01 - 0.03
Fluoranthene	0.03	0.10 – 1.7	0.03	0.00 – 1.0	0.01	0.02 – 0.08
Benzo(b+k)fluoranthene	0.01	3.2 – 31	0.01	0.08 – 10.1	0.00	0.52 – 2.1
Pyrene	0.00	0.01- 0.09	0.00	0.00 – 0.06	0.00	0.00

3.3.2 Sewage treatment plant

There are insufficient data available to obtain $PNEC_{micro-organism}$ values for the individual PAHs in a STP. However, based on the assumption that the PNECs have to be in the µg/l range or higher, it is not expected the calculated concentrations for the CTPHT production sites (see table 3.67) will pose a risk for micro-organisms in a STP (**conclusion ii**).

The down stream users of CTPHT do not emit waste water to a STP

3.3.3 Terrestrial compartment

In Table 3.29 the RC for agricultural soil is presented for the production. For the industrial use the RC is listed inTable 3.30 and Table 3.31. In accordance to the EU TGD, for all PAHs with a log Kow > 5 an additional factor of 10 is applied to the $PNEC_{soil}$ in case no experimental data are available and by extension the equilibrium partitioning approach is used. The risk assessment is based on the local concentration for terrestrial compartment without taking the regional background concentration into account.

3.3.3.1 Production

Table 3.29 Clocal/PNEC for agricultural soil for the different CTPHT production sites.

Substance/Site	1	3	4	5	6	7	8	9
Naphthalene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Acenaphthene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Acenaphthylene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fluorene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Anthracene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Phenanthrene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fluoranthene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pyrene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Benzo(a)anthracene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chrysene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Substance/Site	1	3	4	5	6	7	8	9
Benzo(a)pyrene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Benzo(b)fluoranthene	0.3	0.2	0.1	0.0	0.1	0.1	0.2	0.2
Benzo(k)fluoranthene	0.1	0.1	0.0	0.1	0.1	0.0	0.1	0.0
Benzo(ghi)perylene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dibenzo(a,h)anthracene	0.4	0.3	0.1	0.2	0.2	0.1	0.3	0.3
Indeno(1,2,3-cd)pyrene	0.1	0.1	0.0	0.1	0.0	0.0	0.1	0.1
Sum PAH	**0.95**	**0.69**	**0.2**	**0.5**	**0.5**	**0.2**	**0.7**	**0.5**

3.3.3.2 Industrial use/processing

Table 3.30 Clocal/PNEC for agricultural soil and grassland for the ferro-alloy and graphite industry.

	agricultural soil	
Substance/Scenario	**Ferro-Alloy**	**Graphite**
Naphthalene	0.0	0.0
Acenaphthene	0.0	0.0
Acenaphthylene	0.0	0.0
Fluorene	0.0	0.0
Anthracene	0.0	0.0
Phenanthrene	0.0	0.0
Fluoranthene	0.0	0.0
Pyrene	0.0	0.0
Benzo(a)anthracene	0.1	0.1
Chrysene	0.2	0.4
Benzo(a)pyrene	0.2	0.0
Benzo(b)fluoranthene	0.7	0.5
Benzo(k)fluoranthene	-	-
Benzo(ghi)perylene	0.3	0.2
Dibenzo(a,h)anthracene	0.5	0.3
Indeno(1,2,3-cd)pyrene	0.5	0.3
Sum of PAH	**2.6**	**1.7**

See for a description of the other scenarios table 3.73. graphite: production of graphite electrodes (including paste preparation using a wet process for cooling)

Table 3.31 CLocal/PNEC agricultural soil at primary aluminium production and anode baking sites.

Use cat.	Site	Naphthalene	Acenaphthene	Acenaphthylene	Fluorene	Anthracene	Phenanthrene	Fluoranthene	Pyrene	Benz(a)anthracene	Chrysene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(k)fluoranthene	Benzo(ghi)perylene	Dibenzo(a,h)anthracene	Indeno(1,2,3-cd)pyrene	Total Clocal/PNEC
VSS II	S1	6.7E-04	3.6E-03	1.1E-03	1.3E-03	3.2E-03	2.0E-03	3.8E-03	3.3E-03	4.3E-02	1.4E-01	1.4E-01	5.2E-01		2.7E-01	3.7E-01	3.8E-01	1.9
VSS II	S3	1.7E-03	9.3E-03	2.9E-03	3.4E-03	8.2E-03	5.2E-03	9.8E-03	8.4E-03	1.1E-01	3.7E-01	3.7E-01	1.3E+00		7.0E-01	9.6E-01	9.9E-01	4.9
VSS II	S4	1.8E-03	9.8E-03	3.1E-03	3.6E-03	8.8E-03	5.5E-03	1.0E-02	8.9E-03	1.2E-01	3.9E-01	3.9E-01	1.4E+00		7.5E-01	1.0E+00	1.1E+00	5.2
VSS I	S5	1.9E-03	1.0E-02	3.2E-03	3.7E-03	6.4E-03	2.4E-03	4.1E-03	5.3E-03	1.1E-01	3.8E-01	4.1E-01	2.0E+00		9.3E-01	5.4E-01	1.1E+00	5.5
VSS I	S6	1.8E-03	1.0E-02	3.1E-03	3.5E-03	6.1E-03	2.3E-03	4.0E-03	5.1E-03	1.1E-01	3.7E-01	4.0E-01	1.9E+00		9.0E-01	5.2E-01	1.1E+00	5.3
Anode I	PA1	7.0E-04	3.4E-03	2.1E-05	7.9E-04	5.5E-03	2.3E-03	4.0E-03	3.8E-03	7.8E-02	2.6E-01	1.1E-01	9.3E-01		3.2E-01	1.1E+00	4.5E-01	3.2
Anode I	PA2	3.0E-04	1.4E-03	8.9E-06	3.4E-04	2.3E-03	9.7E-04	1.7E-03	1.6E-03	3.3E-02	1.1E-01	4.5E-02	3.9E-01		1.4E-01	4.6E-01	1.9E-01	1.4
Anode I	PA3	2.7E-07	1.3E-06	8.0E-09	3.1E-07	2.1E-06	8.8E-07	1.5E-06	1.5E-06	3.0E-05	1.0E-04	4.1E-05	3.6E-04		1.2E-04	4.2E-04	1.7E-04	0.001
Anode I	PA4	3.1E-05	1.5E-04	9.2E-07	3.5E-05	2.4E-04	1.0E-04	1.8E-04	1.7E-04	3.4E-03	1.2E-02	4.7E-03	4.1E-02		1.4E-02	4.8E-02	2.0E-02	0.14
Anode I	PA5	1.9E-04	9.2E-04	5.6E-06	2.1E-04	1.5E-03	6.1E-04	1.1E-03	1.0E-03	2.1E-02	7.1E-02	2.9E-02	2.5E-01		8.7E-02	2.9E-01	1.2E-01	0.9
Anode I	PA6	6,7E-04	3,3E-03	2,0E-05	7,6E-04	5,3E-03	2,2E-03	3,8E-03	3,6E-03	7,4E-02	2,5E-01	1,0E-01	8,9E-01		3,1E-01	1,0E+00	4,3E-01	3,1E+00
Anode I	PA6	1.8E-03	8.8E-03	5.4E-05	2.1E-03	1.4E-02	5.9E-03	1.0E-02	9.8E-03	2.0E-01	6.8E-01	2.8E-01	2.4E+00		8.4E-01	2.8E+00	1.2E+00	8.4
Anode I	PA7	2.8E-05	1.3E-04	8.3E-07	3.1E-05	2.2E-04	9.0E-05	1.6E-04	1.5E-04	3.1E-03	1.0E-02	4.2E-03	3.7E-02		1.3E-02	4.3E-02	1.8E-02	0.1
Anode I	PA8	6.7E-06	3.3E-05	2.0E-07	7.6E-06	5.3E-05	2.2E-05	3.8E-05	3.6E-05	7.5E-04	2.5E-03	1.0E-03	8.9E-03		3.1E-03	1.0E-02	4.3E-03	0.031
Anode I	PA9	1.6E-02	7.7E-02	4.7E-04	1.8E-02	1.2E-01	5.1E-02	9.0E-02	8.5E-02	1.7E+00	5.9E+00	2.4E+00	2.1E+01		7.3E+00	2.4E+01	1.0E+01	73
Anode I	PA10	1.7E-04	8.5E-04	5.2E-06	2.0E-04	1.4E-03	5.7E-04	1.0E-03	9.5E-04	1.9E-02	6.6E-02	2.7E-02	2.3E-01		8.1E-02	2.7E-01	1.1E-01	0.8
Anode I	PA11	6.7E-04	3.3E-03	2.0E-05	7.6E-04	5.3E-03	2.2E-03	3.8E-03	3.6E-03	7.4E-02	2.5E-01	1.0E-01	8.9E-01		3.1E-01	1.0E+00	4.3E-01	3.1
Anode I	PA12 1)	1.9E-05	9.2E-05	5.6E-07	2.1E-05	1.5E-04	6.1E-05	1.1E-04	1.0E-04	2.1E-03	7.1E-03	2.9E-03	2.5E-02		8.7E-03	2.9E-02	1.2E-02	0.09
Anode I	PA13	2.4E-03	1.2E-02	7.2E-05	2.7E-03	1.9E-02	7.9E-03	1.4E-02	1.3E-02	2.7E-01	9.1E-01	3.7E-01	3.2E+00		1.1E+00	3.7E+00	1.6E+00	11
Anode I	PA14	1.8E-03	8.8E-03	5.4E-05	2.1E-03	1.4E-02	5.9E-03	1.0E-02	9.8E-03	2.0E-01	6.8E-01	2.8E-01	2.4E+00		8.4E-01	2.8E+00	1.2E+00	8.4
Anode I	PA15	8.1E-07	3.9E-06	2.4E-08	9.2E-07	6.4E-06	2.6E-06	4.6E-06	4.4E-06	9.0E-05	3.0E-04	1.2E-04	1.1E-03		3.7E-04	1.2E-03	5.2E-04	0.004
Anode I	A1 1)	9.9E-03	4.8E-02	3.0E-04	1.1E-02	7.8E-02	3.2E-02	5.6E-02	5.3E-02	1.1E+00	3.7E+00	1.5E+00	1.3E+01		4.5E+00	1.5E+01	6.3E+00	45.8

3.3.3.3 Regional background in soil

Based on the mean values for arable land, grassland, forest and urban soil there is a potential risk for soil organism (see Table 3.32).

Table 3.32 Ratio between the background concentration in different soils presented by Wilcke (2000) PNEC for soil organism

Compound	Arable land	grassland	Forest soil	Urban soil
Naphthalene	0.01	0.00	0.03	0.04
Acenaphthylene	0.06	0.01	0.01	0.06
Acenaphthene	0.25	0.58	0.05	1.50
Fluorene	0.00	0.00	0.01	0.02
Phenanthrene	0.01	0.01	0.03	0.11
Anthracene	0.02	0.01	0.07	0.45
Fluoranthene	0.04	0.03	0.08	0.54
Pyrene	0.04	0.03	0.07	0.59
Benzo(a)anthracene	0.49	0.33	0.54	5.53
Chrysene	0.40	0.38	2.13	5.05
Benzo(b)fluoranthene	0.12	0.12	0.56	1.63
Benzo(k)fluoranthene	0.04	0.07	0.69	0.87
Benzo(a)pyrene	0.34	0.36	0.74	6.60
Indeno(1,2,3-cd)pyrene	0.12	0.11	0.63	2.98
Dibenzo(a,h)anthracene	0.20	0.19	0.28	1.02
Benzo(ghi)perylene	0.11	0.16	0.36	2.18
total	1.89	2.05	4.37	24.61

3.3.4 Atmosphere

Due to the lack of data, no PNEC has been established for the atmospheric compartment. In the risk assessment for man indirectly exposed to the environment the exposure to air concentrations in the vicinity of the different plants is considered. It is to be expected that any precautions necessary to limit that risk will also be protective for wild life.

3.3.5 Secondary poisoning

In the absence of sufficient toxicity data, a PNECoral for none of the PAHs can be derived. The risk assessment is also hampered by the lack of sufficient information on the bioaccumulation potential in fish. Therefore, a realistic quantitative risk assessment for secondary poisoning for the PAHs can not be made.

CTPHT has been indentified as PBT and vPvB, as several PAHs, like B(a)P, are identified as PBT and/or vPvB substances. Therefore it is also not considered necessary to perform a full risk assessment for secondary poisoning, as companies already have to take the most effective measures to minimise the emission of PAHs to the environment with automatically will reduce the risk for secondary poisoning.

To illustrate the potential risk the following preliminary assessment for B(a)P is made:

All BCF values for fish were not considered reliable, although a value of 600 could be used as an upper limit. For mussels reliable BCF values for mussels are available which are on average around 100,000. Based on this value as a worst case estimate for mussel-eating birds and mammals, a concentration in the water phase of > 14 ng/l will lead to concentrations in mussels that exceeds the preliminary PNEC oral of 1.4 mg/kg food, which is the case for some of the uses of CTPHT.

It should be noted that the PNEC for aquatic compartment is 22 ng B(a)P/l, indicating that it might also be protective for secondary poisoning.

3.3.6 PBT assessment

Based on the following information CTPHT meets the P, vP, B, vB and T criteria and hence is considered as a PBT and vPvB substance.

- Most of the PAHs in CTPHT have a DT_{50} value both in soil and sediment > 125 days.
- The BCF values for fluorene, anthracene, phenanthrene, fluoranthene and pyrene were measured > 2000. For anthracene, phenanthrene and fluoranthene the BCF values were > 5000.
- The aquatic NOEC of all EPA 16 PAHs are < 0.01 mg/l
- Most of the (higher molecular) PAHs are present in CTPHT in more than 0.1%.

3.3.7 Areas of uncertainty in the environmental risk assessment

Adsorption and bioavailability

Uncertainties exist towards the sorption and bioavailability of PAHs. As highlighted in section 3.1.4.2.1, PAHs can be sorbed to amorphous organic matter (traditionally referred to as organic carbon), to black carbon BC and other carbonaceous geosorbents (CG), which have differential adsorption properties. Consequently, the Koc value can show a high degree of variation. Hence, the fate and behaviour of PAHs will depend on how PAHs are emitted (gas or particle bound), the characteristics of particles to which the PAHs are bound and the characteristics of the soil or sediment. In addition, sorption of PAHs will also depend on the concentration. The results of the research on the particle affinity of PAHs associated with coal tar pitch (Naes and Ruus, 2007) suggests that the Koc values in sediment in the vicinity of aluminium smelters are higher than those used in the present risk assessment. However, no clear relationship could be found between the characteristics of the sediment and Koc values measured and no difference with clean sediment was demonstrated, which hamper the implementation of these results in a generic approach.

In addition, the effect of the sorption on carbonaceous materials on uptake of PAHs by biota is still unclear. Where some studies show that uptake of PAHs is significantly decreased in the presence of carbonaceous materials, others show that this effect is not present or negligible.

It should be noted that in the present risk assessment, the impact of a change in Koc values will be limited as for most high molecular PAHs both the PEC and the PNEC are derived by using equilibrium partitioning. Consequently, by taking a different Koc value both values will change in the same extent and in concomitant the PEC : PNEC ratio will remain the same. It should also be noted that most of the high molecular PAHs are emitted particle-bound and as such contaminate sediment via direct deposition without dissolving first and partitioning to sediment, successively.

Therefore, for a refinement of the risk assessment monitoring data for all relevant sites are needed together with information on the composition of the organic material present. In addition, it is also crucial to obtain toxicity data for sediment and soil dwelling organism for the high molecular PAHs preferable in relation to the binding to various organic carbon material present.

Ageing

The bioavailability may also depend on the age of the particles. Several studies indicate that bioavailability decreases with increasing residence time. The extent of aging seems to be dependent on the organic carbon content. As no ageing effect were found at an organic carbon content of standard soil (2%) and the fact that this phenomenon is not sufficiently quantified, aging is as yet not considered in the risk assessment.

Information on the release of the individual PAHs

Another factor of uncertainty is the emission estimated for the individual PAHs. In most cases the emissions are reported as B(a)P only or total PAHs and not specified for the individual PAHs. As been described in section 3.1.3.3 for each process one general emission profile is used to estimate the emission of the single PAHs. Consequently, the actual emission of the PAHs could deviate.

Prediction air concentration

The measured data shows that the modelled air concentration can be considered as a conservative prediction. A more accurate measure of air concentration is difficult to make with the generic tools available and can only be obtained by local measurements taking into account the site-specific conditions.

4 HUMAN HEALTH

5 RESULTS

5.1 ENVIRONMENT

Aquatic compartment (incl. sediment)

Based on the risk characterisation ratios derived above it can be concluded that a risk to water and sediment could exist for some CTPHT production sites and at sites using CTPHT for anode, electrode baking and in Søderberg anodes.

CTPHT production:

Conclusion (i) on hold applies for production site 9 as the sum of the PEC/PNEC for all PAHs is > 1 for sediment.

To refine the $PNEC_{sediment}$ there is need for information on the toxicity for sediment dwelling organisms of benzo(a)anthracene, chrysene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(ghi)perylene, dibenzo(a,h)anthracene and indeno(1,2,3-cd)pyrene. (production site 9).

Conclusion (ii) applies to production site 1, 3, 5, 6, 7 and 8.

Conclusion (iii) applies for production site 4. For site 4 there is a need for limiting the risk beside the risk reduction measures which are already being applied, as for this site the $Clocal/PNEC_{water}$ ratios are higher than 1 based on PAHs for which the $PNEC_{water}$ is derived from a complete data set and the local concentrations were based on site specific emission data.

industrial use/processing:

Conclusion (i) applies to industry using CTPHT for the production of binder for coal briquetting, clay pigeons and heavy duty corrosion protection (see section 2.2.3). Industry is requested to provide information on the release of PAHs from production and use of these types of use.

Conclusion (ii) applies to the following primary aluminium plants: plants S5 and S6 (using Søderberg anodes) and plants PA3, PA4, PA6, PA8 and PA9 (using prebakes anodes with an anode production on-site), as they do not emit to water. Conclusion (ii) also applies to site PA15 where the PEC/PNEC ratio is below 1 for water and sediment. Furthermore conclusion (ii) applies for all primary aluminium plants using prebaked anodes without an anode plant on site and the graphite industry as the emission of PAHs is negligible. No further information is considered necessary.

Conclusion (iii) applies to the primary aluminium plants S1, S3, S4, PA1, PA2, PA5, PA7, PA10, PA11, PA12, PA13, PA14, and anode production site A1 with respect to surface water and sediment, as here the Clocal/PNEC ratios are higher than 1, even based on PAHs for which a complete data set is available and the calculated local concentrations are based on measured emission data. More information on the chronic toxicity of the PAHs mentioned above could be considered for further refinement of the PNECs to determine the extent in which the emission to water have to be reduced to exclude a risk for the aquatic environment. There are also indications that PAH in sediments around aluminium smelters might be less bioavailable than the extent calculated by the methods used. More research is needed to elucidate this aspect.

Conclusion (iii) applies to the ferro alloy industry. This use category has been assessed using emission rates to water obtained from literature and emission profiles based on those used for VSS. Using the available information to estimate the emission to water Clocal/PNEC ratios are higher than 1 for PAHs for which a complete data set is available for water (fluoranthene) and sediment (benzo(a)anthracene).Terrestrial compartment

STP

Conclusion (i) applies to industry using CTPHT for the production of binder for coal briquetting, clay pigeons and heavy duty corrosion protection (see section 2.2.3). Industry is requested to provide information on the release of PAHs from production and use of these types of use.

Conclusion (ii) applies to all CTPHT production sites and the main downstream users assessed in the RAR.

Terrestrial compartment

CTPHT production

Conclusion (ii) applies to all CTPHT production sites.

Industrial use/processing:

Conclusion (i) on hold applies to the ferro-alloy industry, graphite industry, anode production industry (including prebake primary aluminium industry with on-site anode production plant) and primary aluminium industry using Søderberg technology others than mentioned above as the sum of Clocal/PNEC is higher than 1 mainly based on PNECs which were determined with equilibrium partitioning or where additional toxicity data could refine the PNEC. Further testing is needed to elucidate the chronic toxicity for soil organisms of benz(a)anthracene[2] chrysene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenzo(a,h)anthracene and indeno(1,2,3-cd)pyrene, benzo(ghi)perylene.

For site PA2, S3 and S4 measured B(a)P concentrations in air were more than a factor of 10 lower than the predicted concentrations. As the contamination of soil at these sites is determined by atmospheric deposition, this would mean that the PAH concentrations in soil will deviate in the same extent, provided that the measurements are reliable and representative. The PEC/PNEC ratio for both sites is < 10. Consequently, the risk for soil organisms might also be low.

---

[2] The PNEC for benz(a)anthracene is based on an high extrapolation factor to normalise it from 90 to 2% o.c. This might be overconservative

Conclusion (i) also applies to industry using CTPHT for the production of binder for coal briquetting, clay pigeons and heavy duty corrosion protection (see section 2.2.3). Industry is requested to provide information on the release of PAHs from production and use of these types of use.

Conclusion (ii) applies to the primary aluminium plant PA3, PA4, PA5 PA7, PA8, PA10, PA12 and PA15. Conclusion (ii) also applies to all primary aluminium plants using prebaked anodes without an anode plant on site as the emission of PAHs is negligible.

Atmosphere

Due to the lack of data, no PNEC has been established for the atmospheric compartment. In the risk assessment for man indirectly exposed to the environment the exposure to air concentrations in the vicinity of the different plants is considered. It is to be expected that any precautions necessary to limit that risk will also be protective for wild life.

Secondary poisoning

In the absence of sufficient toxicity data, a PNECoral for none of the PAHs can be derived. The risk assessment is also hampered by the lack of sufficient information on the bioaccumulation potential in fish. Therefore, a realistic quantitative risk assessment for secondary poisoning for the PAHs can not be made.

CTPHT has been indentified as PBT and vPvB, as several PAHs, like B(a)P, are identified as PBT and/or vPvB substances. Therefore it is also not considered necessary to perform a full risk assessment for secondary poisoning, as companies already have to take the most effective measures to minimise the emission of PAHs to the environment with automatically will reduce the risk for secondary poisoning.

5.2 HUMAN HEALTH