Benzene:

(1st Priority List)
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Strategy For Limiting Risks
(Environment)

Draft of July 13, 2004 (amended January 2006)

Contents

Abbreviations

a:	annum (year)
BAT:	Best Available Technique
BREF:	BAT Reference Document
BTX:	Benzene, Toluene, Xylene
d:	dies (day)
CSTEE:	Scientific Committee on Toxicity, Ecotoxicity and the Environment
Dec.:	decision(s)
EC:	European Community
EC_{50}:	Effective Concentration at wich 50% of the test organisms are affected
EEC:	European Economic Community
ELV:	Emission Limit Value
EQS:	Environmental Quality Standard
EU:	European Union
g:	gramme
h:	hora (hour)
IPPC:	Integrated Pollution Prevention and Control
kg:	kilogramme
l, L:	litre
LVOC :	Large Volume Organic Chemicals
m:	metre
MSDS:	Material Safety Data Sheet
ng:	nanogramme
NOEC:	No Observable Effect Concentration
NMVOC:	Non-Methane Volatile Organic Compounds
OJ:	Official Journal
PEC:	Predicted Environmental Concentration
PNEC:	Predicted No Effect Concentration
Pow:	octanol-water partition coefficient
RAR:	Risk Assessment Report
t:	tonne, tonnes
TGD:	Technical Guidance Document
UBA:	Umweltbundesamt (Federal Environmental Agency of Germany)
VOC:	Volatile Organic Compounds
WFD	Water Framework Directive
WWTP:	Waste Water Treatment Plant
µg:	microgramme

Summary

Benzene is produced from crude oil, condensate from natural gas production or coke oven by-products. The estimated production amount in the EU is 7 247 kt/a (1994-2001). Substantial production also takes place in Eastern Europe. 576 128 t/a are imported into the EU, 128 902 t/a are exported (1994). In the European Union benzene may be used as an intermediate in industrial processes only. Additional emissions arise from non-isolated benzene (e.g. in petrol) and from benzene produced during petrol combustion.

The environmental risk assessment of benzene (draft of March 25, 2003) identifies risks

- to industrial wastewater treatment plants (WWTPs) at production and/or processing sites (generic scenario and 23 out of 48 known sites)
- to the aquatic environment at production and/or processing sites (generic scenario and 2 out of 48 known sites)
- to the atmosphere because of the contribution of benzene to the formation of tropospheric ozone.

Current Risk Reduction Measures

Benzene is classified as carcinogenic (cat. 1), toxic, mutagenic (cat. 2), irritant and harmful.

According to Directive 76/769 benzene may be used in industrial processes only.

The reductions of the emissions arising from production and processing of benzene are basically covered by the IPPC Directive. The relevant BAT Reference Documents (BREFs) are the BREF on the large volume organic chemical (LVOC) industry, the BREF on mineral oil and gas refineries and the BREF on iron and steel production. These BREFs give some information on best available techniques (BAT) for emission control of benzene or VOC (volatile organic compounds).

Emissions of benzene (as a commercial product) to air are regulated under Directive 2000/69/EC (limit value for benzene in ambient air), the NEC Directive (national emission ceilings for VOC emissions, environmental objectives for ground-level ozone) and Directive 2002/3/EC (long-term objectives, target values, alert and information thresholds for ozone in ambient air).

Under the Water Framework Directive an environmental quality standard (EQS) will be adopted for benzene in surface waters (including transitional, coastal and territorial waters). A maximum acceptable benzene concentration in drinking water is in place according to Directive 98/83/EC. National quality standards for benzene in surface waters have been established due to the provisions of Directive 76/464/EEC. The International Commission for the Protection of the Rhine (ICPR) has set a water quality target. Finally in some Member States there are further provisions.

Possible Further Risk Reduction Measures and their Assessment

Recently adopted EU legislation as described above is already going to affect the identified risks. Existing measures with regard to air pollution control are considered appropriate and sufficient for the protection of human health and the environment from tropospheric ozone, which is partly formed from benzene in the environment.

Under the Water Framework Directive the Community-wide EQS for benzene will be well below the $PNEC_{aqua}$. The Commission then has to submit proposals of controls for the emission reduction of benzene and take account of Community-wide uniform emission limit values (ELVs) for process controls. Therefore no further measures are necessary for the protection of surface waters from benzene. If it can be ensured that ELVs below the $PNEC_{microorganism}$ are established, the potential risks to industrial WWTPs could be eliminated in this way. This measure is considered effective and practicable and is probably not associated with high costs.

The IPPC Directive will also contribute to the reduction of benzene emissions. To demonstrate the functioning of the industrial WWTPs the concentrations cited in the BREFs (mineral oil and gas refineries and iron and steel production) have to be met. The BREF on large volume organic chemicals (LVOC) does not mention any benchmarks for concentrations of benzene and/or other parameters in the WWTP effluents and gives only few information on benzene secondary products.

The risk to industrial WWTPs could be limited by process-integrated measures or by installation of a wet air oxidation or a stripping facility prior to biological treatment. To some extent this is already reflected in the LVOC BREF. Since the BREFs are not binding, the actual technical level in the Member States depends on the way of implementation of BAT by the respective Member States and/or the permitting authorities. In summary it is difficult to predict the implications of the IPPC Directive. However, the results of the benzene risk assessment and potential emission reduction measures for benzene should be reflected in the BREF on LVOC as far as possible.

Existing national laws could be used to reduce effects of benzene on surface waters and industrial wastewater treatment plants before EU-wide measures have an impact.

Further Risk Reduction Measures Recommended

Existing Community legislation is considered appropriate and sufficient for the protection of the environment from benzene emissions to surface waters and from tropospheric ozone, which is partly formed from benzene in the environment.

The following risk reduction measures are recommended for the elimination of potential risks to industrial WWTPs at benzene production and/or processing sites:

- Under the Water Framework Directive it should be ensured that emission limit values below the $PNEC_{microorganism}$ (1.3 mg/l) are going to be established. [However, this recommendation has been deleted after discussions at the Risk Reduction Meeting. At industrial WWTPs benzene removal is carried out by an adapted biological system. It is in the interest of the companies not to overload their system. Implementation of BAT is considered to be sufficient for risk reduction.]
- The results of the benzene risk assessment and potential emission reduction measures for benzene should be taken into account in the next revision of the BREF on LVOCs and if necessary in the horizontal BREF for the chemical sector.
- Existing national laws could be used to reduce effects of benzene on industrial wastewater treatment plants before EU-wide measures have an impact.

Methodological and information problems

For 23 production and/or processing sites risks to industrial WWTPs and for 2 sites risks to surface waters have been identified. The respective calculations rely on TGD default values.

Chances are that there are no actual risks to industrial WWTPs, because

- default values represent a worst case situation,
- operators probably would take notice of any dysfunctions in their WWTPs and take appropriate abatement measures,
- especially industrial WWTPs can get adapted to high contaminant concentrations.

If there are actually any impacts of benzene on the functioning of industrial WWTPs, there might be further risks to surface waters from the respective sites. In the risk assessment the PEC/PNEC calculations for the aquatic compartment always assume that the WWTPs are fully functioning (93.9% benzene elimination).

In the calculations of the $Clocal_{water}$ for all benzene producing and/or processing companies it was assumed that the companies are connected to an in-house biological WWTP. This means that considerably higher concentrations in surface water can be expected if individual companies release their wastewater directly into the receiving stream as direct dischargers.

1. Background

Benzene is on the first priority list[1] of substances drawn up under Council Regulation 93/793/EEC[2] on the evaluation and control of the risks of existing substances. Germany is responsible for assessing the risks associated with the manufacture and use of benzene and for developing a Risk Reduction Strategy for those endpoints which pose unacceptable risks for human health and/or the environment.

The environmental risk assessment of benzene (draft of March 25, 2003) identifies risks

- to industrial wastewater treatment plants at production and/or processing sites (generic scenario and 23 out of 48 known sites)
- to the aquatic environment at production and/or processing sites (generic scenario and 2 out of 48 known sites)
- to the atmosphere because of the contribution of benzene to the formation of tropospheric ozone.

Use Pattern

The natural sources of benzene are crude oil and, to a lesser extent, condensate from natural gas production. It is produced by different petroleum conversion processes in petroleum refinery and chemical plant processes, primarily by catalytic reforming, steam cracking and dealkylation. Benzene is recovered during production of coal-derived chemicals, primarily from coke oven by-products. Benzene is extracted from these sources and purified for industrial use.

According to the data available for the Risk Assessment the estimated production of benzene as a chemical intermediate in the European Union is 7 247 kt/a (1994-2001). Substantial production also takes place in Eastern Europe. 576 128 t/a are imported into the EU, 128 902 t/a exported (1994).

Petroleum refinery streams containing benzene are blended with other petroleum streams to formulate petrol. This benzene is not isolated in the refinery process. Until the year 2000 in Europe benzene in petrol was limited to a maximum of 5 % by volume. The average was in the range of 3 - 3.5 %. The new European petrol quality requirements limit benzene in petrol to a maximum of 1.0 % by volume from 01.01.2000 (Directive 98/70/EC[3]). The total quantity of benzene present in petrol used in Western Europe in 2000 may be estimated at 1.41 million tonnes. This benzene used in petrol is in addition to the benzene of chemical intermediate production.

In the chemical industry, benzene is industrially the most important of the so-called BTX aromatics (benzene, toluene, xylene). Benzene forms the basis for a great variety of aromatic intermediates and for the group of cycloaliphatic compounds. Benzene is used as the basis for the manufacture of plastics, synthetic rubber, dyestuffs,

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[1] OJ L 131, May 26, 1994, pp. 3-4.
[2] OJ L 084, April 5, 1993, pp. 1-75.
[3] OJ L 350, December 28th, 1989, pp. 58-68

resins, raw materials for detergents and plant protection agents. The most important secondary products manufactured from benzene in Western Europe in 1994 are presented in Table 1. There are 50 known production and/or processing sites of benzene within the EU.

Table 1: Secondary products manufactured from benzene (RAR, draft of March 25, 2003)

Secondary product manufactured from benzene	Fraction of total benzene use [%]	Secondary product used for production of
Ethyl Benzene	52	styrene and polystyrene
Cumene	20	phenol
Cyclohexane	13	nylon
Nitrobenzene	9	aniline dyes, polyurethane foams
Alkylbenzene	3	surfactants
Maleic anhydride and others	2	unsaturated polyester resins, plant protection agents, lubricating oil additives, antioxidants for oils and grease
Chlorobenzene	1	plant protection agents, pharmaceuticals, dyestuffs, rubber auxiliaries, textile auxiliaries, disinfectants and air deodorizers. Chlorobenzenes are also used in the chemical industry as solvents and oils, greases, resins, rubber, ethylcellulose, etc.

Very small quantities are also used as a laboratory reagent and solvent. This use is declining. However, benzene does occur in small quantities in various solvents on a hydrocarbon basis.

Since benzene is a natural component of crude oil, it is an intrinsic constituent of certain refinery fractions, or it is formed during the refining process in use today. As a result, benzene as a component of refinery products also ends up in consumer products.

2. The Risk Assessment

In the following the results of the RAR (draft of March 25, 2003) are summarized as far as they are relevant for the Risk Reduction Strategy.

Benzene is highly volatile (vapour pressure of 99.7 hPa at 20°C). Its water solubility is 1.8 g/l (25°C). Benzene is readily biodegradable, the half life in surface waters is estimated to be 15 d. Anaerobic degradation is not expected. Hydrolysis and direct photolysis under environmental conditions are not likely to occur. For the degradation of benzene in air by reaction with hydroxyl radicals, a half-life of 13.4 d is calculated. Benzene has no significant potential for geo- and bioaccumulation (log Pow 2.13).

2.1 Exposure

Benzene is used and emitted in large quantities. Because benzene is a volatile organic compound, it is mainly emitted to the air and emissions to soil and water partly result in emission to the air. As a result most of the benzene is found in the air compartment.

Benzene is released from a number of man-made sources. The primary sources of environmental benzene are automobile exhaust emissions, evaporative losses and refuelling emissions. Benzene in automotive exhaust is a mixture of incompletely burned benzene and benzene produced in the motor during combustion through dealkylation of toluene and xylenes. From industrial sources, it primarily enters the environment as fugitive emissions from industrial intermediate production and processing operations and through air emissions from wastewater treatment plants. Natural sources of benzene emissions such as vulcanos and forest fires exist.

In the RAR the exposure situation in the EU that results from industrial sources of pure benzene production and processing is described quantitatively. Data from 48 of 50 benzene production and/or processing sites are presented. If no further information was available, it was assumed that a company discharges its wastewater to a WWTP. 14 production sites, 22 production and processing sites and 12 processing sites were identified during the risk assessment. A quantity of 1 868.8kt/a of benzene is processed at unknown sites and a generic scenario with the default values from the TGD was used to estimate the emission of benzene to air and water from these unknown sites (processing quantity 100 000 t/a). 1 868.8 kt/a is about one quarter of the total amount of benzene processed in the EU.

Based on the physico-chemical properties of benzene and the rate constant for biodegradation of 1 h^{-1} the elimination in WWTPs can be determined with the help of the SIMPLETREAT model as shown in Table 2.

Table 2: Behaviour of benzene in WWTP's (RAR, draft of March 25, 2003)

Evaporation to air (%)	42.6
Release (dissolved) to water (%)	6.1
Adsorption to sewage sludge (%)	1.2
Degradation (%)	50.1
total elimination from water (%)	93.9

For six benzene producing companies elimination in the WWTP could be calculated from measured influent and effluent concentrations. The elimination ranged from 90 to > 99%, which is in the same order of magnitude as the elimination calculated with the SIMPLETREAT model. Therefore the latter is used as a default when site specific data are not available.

Measured effluent concentrations of WWTPs ranged from detection limit (<1 to 100 µg/l) to 78 000 µg/l. Concentrations calculated from the production volume and site specific exposure information or the TGD default emission factors range from 43 µg/l to 2.5 g/l for influent and from 1 µg/l to 101 700 µg/l for effluent concentrations. It should be noted that the highest calculated values are based on the use of TGD default values.

The main sink of benzene is the degradation with OH radicals in the troposphere (half life of 13.4 d calculated for the northern hemisphere conditions). The addition of OH to the benzene ring is followed by further reactions, e.g. with oxygen, nitrogen dioxide or by ring opening, to form phenol, nitrobenzene, nitrophenol, dinitrobenzene, methylnitrophenols, formaldehyde, formic acid, maleic anhydride, glyoxal, butenedial, acroleine and carbonmonoxide.

Benzene is a volatile organic compound (VOC) , which contributes to the formation of tropospheric ozone. The formation of tropospheric ozone involves complicated chemical reactions between NOx and VOC driven by the solar radiation. In order for these reactions to occur in substantial quantities, meteorological conditions must prevail that prevent dispersion of NOx and hydrocarbons. After a night time accumulation NOx reacts with sunlight to produce NO and highly reactive atomic oxygen. The atomic oxygen may react with many compounds in the air, i.e. O_2 to produce O_3 or VOC to produce free radicals. The time scale of ozone production is such that ozone concentrations may build up over several days under suitable weather conditions, and that this pollutant and its precursors can be transported over considerable distances.

To evaluate the relative importance of benzene for the creation of tropospheric ozone the VOC composition within the region of concern has to be known. For a simple evaluation of the relative importance of the isolated commercial product benzene for the creation of ozone the VOC composition from industrial sources as well as the VOC composition from other sources, e.g. traffic emissions, has to be known. For a more in depth evaluation also the solar radiation and the NOx concentrations have to be taken into account. These will vary considerably throughout Europe, between regions and between individual sites within the region as will also the VOC composition which depends on composition of the regional/local industrial sector and the traffic.

Total continental emission to air of isolated benzene (direct and from WWTPs) is calculated to be about 72 000 t/a based on the production volume from 1994 - 2001. The mean total emission of non-methane volatile organic compounds (NMVOC) in 1994 to 1997 is approx. 13 000 kt/a. Thus isolated benzene in general only contributes to a small extent to the total SMOG problem. However, for a single substance among hundreds of different VOCs the contribution is significant.

With the SimpleBox model regional and continental air and water concentrations have been calculated:

Table 3: Comparison of SimpleBox and monitoring concentrations (RAR draft of March 25, 2003)

Compartment	**SimpleBox**		**Monitoring**
	regional	**continental**	
air	1.54 µg/m^3	0.73 µg/m^3	1.5 - 4.4 µg/m^3 : pristine air 6 - 63 µg/m^3: industrial areas
water (dissolved)	0.275 µg/l	0.03 µg/l	<100-300 ng/l (Rhine) <5 µg/l (Elbe, Hamburg)
sediment	1.35 µg/kg	0.158 µg/kg	2.0 µg/kg

2.2 Effects

A lot of ecotoxicity tests with a variety of different aquatic species were conducted using benzene as a test substance. Because of the high volatility of the substance tests that were conducted in flow-through systems with analytical monitoring of the benzene concentration were preferred for the risk assessment. Most of the tests available are short-term studies.

With regard to short-term exposure of animals and algae the available valid LC/EC_{50} values point to similar susceptibility of sensitive taxa in fish and invertebrates (crustaceae), comparing to a somewhat lower overall sensitivity of algae. The NOEC of 0.8 mg/l from an early life stage test with *Pimephales promelas* is used as basic value for the PNECaqua derivation. Long-term tests with species from three trophic levels are available. Therefore, the application of an assessment factor of 10 on the lowest NOEC is justified.

$$\mathbf{PNEC_{aqua} = 0.8\ mg/l\ /\ 10 = 0.08\ mg/l}$$

The lowest ecotoxicity test result with microorganisms (24 h-EC_{50} = 13 mg/l) was obtained with a test conducted with nitrifying bacteria. According to the TGD an assessment factor of 10 has to be applied to this value.

$$\mathbf{PNEC_{microorganism} = 13\ mg/l\ /\ 10 = 1.3\ mg/l}$$

Benzene contributes to tropospheric ozone formation. Regarding effects of ozone the CSTEE is quoted in their "Opinion on Risk assessment underpinning new standards and thresholds in the proposal for a daughter directive for tropospheric ozone", adopted at the CSTEE by written procedure on May 21, 1999". Qualitative effects of ozone are described:

The effects of ozone on vegetation are reduced photosynthesis, impaired CO_2 fixation and altered cell growth leading to reduction in root/shoot ratios and in flower formation. This may result in ecological balance shifts as less ozone-sensitive species are favoured. Presumably a tolerance phenomenon occurs in plants with continual exposure, though it appears to be poorly documented. For neither man, animals nor for plants has a threshold been established for either acute or chronic effects. This raises the issue of what type and degree of change is of health significance. There are several factors that can affect the toxicity of ozone for plants (different environmental and ecological conditions). Effects on animals and humans are expected within the same range of exposure.

Directive 2002/3/EC[4] gives "long-term objectives" for ozone, which means an ozone concentration in the ambient air below which, according to current scientific knowledge, direct adverse effects on human health and/or the environment as a whole are unlikely (see section 3.3).

2.3 Risk Characterisation

Risks have been identified for industrial wastewater treatment plants, the aquatic environment and the atmosphere.

Risks to industrial WWTPs (Clocaleffl/PNECmicroorganism ratios >1) were identified for 23 out of 48 known production and/or processing sites and for the generic scenario representing unknown benzene processing sites (seeTable 4). For all these sites the Clocaleffl is based on default values. It was not expected to obtain site-specific and traceable exposure data with reasonable efforts and time expenditure. In addition, it was considered not likely that the performance of a test with industrial activated sludge would result in a Clocaleffl/PNECmicroorganism ratio <1 for all sites due to the partly very high benzene concentrations in WWTP effluents (up to 102 mg/l).

For two production and processing sites a risk to the aquatic environment ($PEClocal_{water}/PNEC_{aqua}$ ratio for site PP16: 59.15, for site PP17: 28.63). For both sites the $Clocal_{effl}$ was devided by the default dilution factor of 10 and the regional background concentration of 0.28 µg/l was added to calculate the $PEClocal_{water}$. As

[4] OJ L 067 March 9th, 2002, pp. 14-30

the PEC calculations for these sites are partly based on default values, improvement of the data basis would be possible. During the risk assessment the two sites were repeatedly asked for site-specific exposure data, but did not react. The calculation for the generic scenario “processing of benzene” results in a $PEClocal_{water}/PNEC_{aqua}$ ratio of 89.

In the calculations of the $Clocal_{water}$ for all benzene producing and/or processing companies it was assumed that the companies are connected to an in-house biological WWTP. This means that considerably higher concentrations in surface water can be expected if individual companies release their wastewater directly into the receiving stream as direct dischargers.

The industrial use of the commercial product benzene contributes significantly to the overall air emission of benzene. However, emission of benzene in exhaust gases expelled from motor vehicles seem to be the largest single source. The effects on ozone creation of emissions arising from the production and use of the isolated commercial product benzene may differ substantially between different regions in the EU.

Based on a rough estimation utilising available information, the current risk assessment indicates that emission of benzene from the use and production of the commercial product benzene may be in the order of 0.5 % of total NMVOC emissions. Locally and regionally this proportion may vary substantially due to differences between regions in the VOC emission pattern from industrial sectors using benzene. Even a simple evaluation of the photochemical ozone creation potential of the emission of isolated benzene is difficult to perform, when the emission pattern of individual NMVOCs is not available. On the basis of monitoring of NMVOCs in street air there is indication that non-isolated benzene can contribute with about 2.5 – 7.5 % to the overall ozone formation due to NMVOCs.

Effects of ozone exposure are documented on plants, animals and humans. Reporting on monitoring results are most frequently done in relation to exceedance of thresholds for information or warning of the human population, but this reporting may also give indication on the magnitude of environmental effects, because effect concentrations seem to be in the same order of magnitude for both vegetation and humans. The threshold values set by the European Union to protect human health and the vegetation are frequently exceeded. The severity of exceedance of the EU threshold for health protection (110 νg/m3, 8h average) has been estimated by WHO. The 1995 summer ozone incidence is estimated to have caused 1500-3700 deaths (0.1-0.2% of all deaths) and further 300-1000 extra emergency hospital admissions due to respiratory diseases. It is likely that the total number of health impacts is higher than the estimated impact of the days with high levels only. This is suggested by epidemiological studies where the effects can be seen also below the 110 νg/m3 level. Similarly, the vegetation and wildlife may be severely affected by ozone incidences and benzene is likely to contribute to these effects. However, no simple relationship has been established between the proportion of benzene to total NMVOC emitted - and thus also between emissions arising from the use of the commercial product benzene - and the creation of troposheric ozone.

Table 4: Data used for $Clocal_{effl}$ / $PNEC_{microorganism}$ calculations of benzene production and processing (RAR draft of 25 March 2003, sites with $Clocal_{effl}$ / $PNEC_{microorganism}$ > 1 are highlighted)

Site	Production (kt/a)	Processed (kt/a)	Release fraction to WWTP (t/t)	Release to WWTP (kg/d)	Elimination in WWTP	Volume flow of WWPT[2)]	$Clocal_{effl.}$ (µg/l)	$Clocal_{effl}$ / $PNEC_{microorg.}$
Production								
P1	63	0	2.41E-06	0.51	SimpleTreat	site specific	128.9	0.1
P2	172.05	0	0.003[(*)]	1720.50	site-specific	site-specific	100	< 0.1
P3	77	0	0.000995	255.38	SimpleTreat	site specific	1220	0.9
P4	135	0	0.003[(*)]	1350.00	SimpleTreat	default	41180	31.7
P5	170	0	2.65E-12	0.0000015	/	/	10.0	< 0.1
P6	63.59	0	1.79E-06	0.38	SimpleTreat	site specific	5.0	< 0.1
P7	142.1	0	1.08E-06	0.51	SimpleTreat	site specific	5.0	< 0.1
P8	506	0	1.92E-07	0.32	SimpleTreat	site specific	5.0	< 0.1
P9	250	0	0.003[(*)]	2500.00	SimpleTreat	default	76250	58.7
P10	61	0	0.003[(*)]	610.00	SimpleTreat	default	18610	14.3
P11	64	0	0.0007	149.33	site-specific	site specific	9.3	< 0.1
P12closed 1999								
P13	160	0	0.000013	7	/	/	no wwtp	/
P14	127	0	0.003[(*)]	1270.00	SimpleTreat	default	38740	29.8
Sum:	**1990.74**	**0**	**/**	**7863.94**			**/**	
Prod. And Proc.								
PP1	140	70	0.003/0.007[(*)]	3033.33	SimpleTreat	default	92520	71.2
PP2	170	170	0.01	5666.67	SimpleTreat	site specific	12000	9.2
PP3	110	110	0.000021	7.68	SimpleTreat	site specific	420	0.32
PP4	497.4	377.5	2.47E-6 /6.04E-4	764.13	SimpleTreat	default	23310	17.9
PP5	296	355	/	84.84	site specific	site specific	20.0	< 0.1
PP6	120	120	3.28E-06	1.31	SimpleTreat	default	40.0	< 0.1
PP7	400	400	0.0000505	55.34	site specific	site specific	1.0	< 0.1
PP8	53.7	53.7	0.01[(*)]	1790.00	SimpleTreat	default	54600	42.0
PP9	72	72	0.01[(*)]	2400.00	SimpleTreat	site specific	29280	22.5
PP10	580	640	/	1093.00	SimpleTreat	default	33330	25.6
PP11	100	100	0.01	3333.33	SimpleTreat	default	101700	78.2
PP12	990	990	7.63E-06	25.18	SimpleTreat	site specific	64.0	< 0.1

Site	Production (kt/a)	Processed (kt/a)	Release fraction to WWTP (t/t)	Release to WWTP (kg/d)	Elimination in WWTP	Volume flow of WWPT[2)]	Clocal $_{effl.}$ (µg/l)	$Clocal_{effl}$ / $PNEC_{microorg.}$
PP13	200	400	/	183.33	SimpleTreat	default	5592	4.3
PP14	450	180	/	30.84	SimpleTreat	site specific	115.9	< 0.1
PP15	57	57	0.01[(*)]	1900.00	SimpleTreat	default	57950	44.6
PP16	128	128	0.01[(*)]	4266.67	SimpleTreat	site specific	47320	36.4
PP17	107	107	0.01[(*)]	3566.67	SimpleTreat	site specific	22900	17.6
PP18	50	50	0.01[(*)]	1666.67	SimpleTreat	default	50830	39.1
PP19	10	10	0.01[(*)]	333.33	SimpleTreat	default	10170	7.8
PP20	450	162	/	14.16	SimpleTreat	site specific	280	0.2
PP21 closed								
PP22	275	129	/	56.4	/	/	no wwtp	/
sum:	**5256.1**	**4681.2**	**/**	**30272.88**			**/**	
Processing								
generic scenario	0	100	0.007[(*)]	2333.33	SimpleTreat	default	71167	54.7
Pc1	0	10	0.007[(*)]	233.33	SimpleTreat	default	7117	5.5
Pc2	0	128	0.0000244	8.56	SimpleTreat	site specific	40.4	< 0.1
Pc3	0	48	0.007[(*)]	1120.00	SimpleTreat	site specific	455.5	0.35
Pc4	0	108	0.007[(*)]	2520.00	SimpleTreat	site specific	6149	4.7
Pc5	0	5	0.007	116.67	SimpleTreat	default	3558	2.7
Pc6	0	214.404	0.0000018	1.21	SimpleTreat	default	40	< 0.1
Pc7import only								
Pc8	0	6.4	0.0000043	0.08	SimpleTreat	site-specific	2	< 0.1
Pc9	0	70	0.007[(*)]	1633.33	SimpleTreat	default	49820	38.3
Pc10	0	7	0.007[(*)]	163.33	SimpleTreat	default	4982	3.8
Pc11	0	10	0.007[(*)]	233.33	SimpleTreat	default	7117	5.5
Pc12	0	550	7.30E-07	1.34	SimpleTreat	default	40.8	< 0.1
sum:	**0**	**1156.804**	**/**	**6031.18**			**/**	
Total	**7246.84**	**5838**		**44168**				

(*) based on TGD default values

The RAR concludes that there is a need for limiting the risk from the contributions of the commercial product benzene and of non-isolated benzene to the formation of ozone. In the context of the consideration of which risk reduction measures would be most appropriate, it is recommended that under the relevant air quality Directives a specific in-depth evaluation should be performed. Such an evaluation should focus on the contribution of isolated as well as non-isolated benzene to the complex issue of ozone and smog formation and the resulting impact on air quality.

2.4 Methodological and Information Problems

For 23 production and/or processing sites risks to industrial WWTPs and for 2 sites risks to surface waters have been identified. The respective calculations rely on TGD default values.

Chances are that there are no actual risks to industrial WWTPs, because

- default values represent a worst case situation,
- operators probably would take notice of any dysfunctions in their WWTPs and take appropriate abatement measures,
- especially industrial WWTPs can get adapted to high contaminant concentrations.

If there are actually any impacts of benzene on the functioning of industrial WWTPs, there might be further risks to surface waters from the respective sites. In the risk assessment the PEC/PNEC calculations for the aquatic compartment always assume that the WWTPs are fully functioning (93.9% benzene elimination).

In the calculations of the $Clocal_{water}$ for all benzene producing and/or processing companies it was assumed that the companies are connected to an in-house biological WWTP. This means that considerably higher concentrations in surface water can be expected if individual companies release their wastewater directly into the receiving stream as direct dischargers.

3. Current Risk Reduction Measures

According to Council Directive 89/677/EEC[5] amending for the eighth time Directive 76/769/EEC[6] benzene “may not be used in concentrations equal to, or greater than, 0.1 % by mass in substances or preparations placed on the market. However, this provision shall not apply to (…) substances and preparations for use in industrial processes not allowing for the emission of benzene in quantities in excess of those laid down in existing legislation (…)”. Further legal provisions with regard to benzene and the risks identified in the RAR are summarised in the following sections.

3.1 Classification and Labelling

According to the data presented in the RAR and to the criteria of the Directive 67/548/EEC[7], benzene has not to be classified as dangerous to the environment.

- (Classification according to Annex I)

Highly flammable	R 11	Highly flammable
Carcinogenic, Cat. 1	R 45	May cause cancer
Toxic	R 48/23/24/25	Toxic: danger of serious damage to health by prolonged exposure through inhalation, in contact with skin and if swallowed

Concentration limits: none

- (Proposal of the Rapporteur)
  According to the data presented in the RAR and the criteria of Directive 67/548/EEC the substance has to be classified as:

Highly flammable	R 11	Highly flammable
Carcinogenic, Cat. 1	R 45	May cause cancer
Toxic	R 48/23/24/25	Toxic: danger of serious damage to health by prolonged exposure through inhalation, in contact with skin and if swallowed
Mutagenic, Cat. 2	R 46	May cause heritable genetic damage
Irritant	R 36/38	Irritating to eyes and skin
Harmful	R 65	Harmful: May cause lung damage if swallowed

Benzene is classified as belonging to the German water-hazard class 3 (severely hazardous to water).

[5] OJ L 398, December 30th, 1989, pp. 19-23
[6] OJ L 262, September 27th, 1976, pp. 201-203
[7] OJ L 196, August 16th, 1967, pp. 1-98

3.2 IPPC

The European Integrated Pollution Prevention and Control Directive 96/61/EC[8] (IPPC) sets out common rules on permits for industrial installations. It aims to prevent and, where this is not practicable, to minimise pollution from various point sources throughout the EU. The integrated approach to pollution control prevents the shifting of pollution between the various environmental compartments and thereby promotes the application of the principle of sustainable development.

Installations covered by the IPPC Directive (Annex I of the Directive) need an operating permit which sets limits for emissions to water, air and soil. The permits are granted by the local authorities and must be based on the concept of Best Available Techniques (BAT). The European Commission is to provide guidance on defining a BAT within each industrial sector in the form of BAT Reference Documents (BREF notes). These usually also list the emissions achievable with these techniques. However, the BREFs do not contain any emission limits and are not legally binding. Nevertheless, national authorities have to take them into account when establishing emission limit values (ELVs) or technical measures based on BAT. Existing plants have to comply with the provisions in November 2007 at the latest. The monitoring provisions of the Directive apply.

For the industrial activities listed in Annex I of the Directive Member States are obliged to establish ELVs or technical measures based on BAT. Since risks for the WWTPs of benzene production sites, production and processing sites and pure processing sites have been identified, several categories of industrial activities (IPPC Annex I) are relevant for the risk reduction of benzene:

÷ production of simple hydrocarbons (benzene, ethyl benzene, cumene, cyclohexane, alkylbenzene)
÷ production of oxygen-containing hydrocarbons (maleic anhydride)
÷ production of nitrogenous hydrocarbons (nitrobenzene)
÷ production of halogenic hydrocarbons (chlorobenzene).

Annex III of the IPPC Directive lists the main polluting substances to be taken into account if they are relevant for fixing emission limit values. Annex III includes volatile organic compounds and substances which possess carcinogenic or mutagenic properties or properties which may affect reproduction. Therefore, the emission reduction of benzene is basically covered by the IPPC Directive.

The BREF on BAT in the large volume organic chemical industry (European Commission, 2002) contains generic information on the production of large volume organic chemicals (LVOC) and a chapter with detailed information on aromatics, including benzene. All secondary products produced from benzene also belong to the large volume organic chemicals (production capacity > 100 kt/a). The BREF contains process descriptions for the secondary products ethylbenzene, cumene and maleic anhydride. Only for the ethylbenzene production process benzene is mentioned as a

[8] OJ L 257, October 10, 1996, pp. 26-40

relevant water pollutant. Treatment by wet air oxidation or VOC stripping (prior to biological treatment) is mentioned.

BAT for water emissions at BTX production sites is described as follows:

“The production of aromatics generally has few wastewater arisings. BAT is to minimise wastewater generation and to maximise wastewater re-use.
Where high hydrocarbon levels still exist after full application of prevention and minimisation techniques, then BAT for wastewater exiting the battery limits is the recovery of hydrocarbons using, for example, steam stripping. BAT for the recovered hydrocarbons is either recycling to fuel or to other recovery systems in associated processes within the complex. BAT for the water phase is routing via an oily water separator (to recover hydrocarbons that do leave the battery limits) followed by biological wastewater treatment.”

BAT for minimisation of the VOC emissions to air at benzene production sites is also described in the BREF.

The production of fuels is by far the most important function of refineries and will generally determine the overall configuration and operation. Nevertheless some refineries can produce non-fuel products, e.g. benzene or cyclohexane. In these cases the BREF on BAT for mineral oil and gas refineries (European Commission 2003a) refers to the LVOC BREF. However, the BREFS overlap to some extent and both have to be considered in case of benzene production and processing at refineries. In the refineries BREF it is stated that benzene in general in wastewater can often be treated more easily and effectively at the point it is generated rather than at the WWTP after it is mixed with other wastewater. In this case adequate techniques for the reduction of benzene concentrations in wastewater are, e.g., nitrogen or air stripping or wet air oxidation. However, BAT for the reduction of hydrocarbon and VOC emissions from refineries consists of a bunch of several techniques ranging from process integrated to end-of-pipe measures. According to the BREF refineries using BAT can achieve benzene concentrations of <0.001-0.05 mg/l in their WWTP effluents which is far below the $PNEC_{microorganism}$.

BAT for minimisation of the VOC emissions to air at refineries is also described in the BREF.

In the BREF on the production of iron and steel (European Commission 2001) the environmental aspects of iron and steel making in integrated steelworks (beside others coke oven plants) are covered. For coke oven plants emissions to air are most significant. However, wastewater emissions from coke oven plants belong to the most relevant emissions to water in the iron and steel sector. Benzene is recovered from the raw coke oven gas as a by-product.

Apart from process integrated measures (which rather refer to air emissions) BAT for wastewater treatment from coke oven plants is:

- pre-treatment: efficient ammonia stripping using alkalis, tar removal
- wastewater treatment: biological wastewater treatment with integrated nitrification/denitrification achieving 90% COD removal and certain concentrations for sulphide, PAH, CN-, phenols, sum of NH4+/NO3-/NO2-, suspended solids.

BAT for minimisation of emissions to air from iron and steel production sites is also described in the BREF.

According to the horizontal BREF for the chemical sector (BAT in common waste water and waste gas treatment/management systems) benzene emissions of industrial WWTPs to waters could be limited by process-integrated measures and/or by abatement techniques prior to the biological wastewater treatment, e.g. wet air oxidation or stripping (European Commission 2003b). The BREF mentiones benzene as an inhibitor of nitrogen elimination at a benzene concentration of 500 mg/l. It is emphasised that cautious feeding of low concentrations of toxic substances can result in adaptation of the microorganisms and thus to the complete loss of inhibiting effects, if the concentration is not considerably increased. However, the benzene concentration of 500 mg/l cited in the BREF already is substantially above the $PNEC_{microorganism}$ of 1.3 mg/l derived in the RAR.

3.3 Emissions to Air

Only measures with regard to the commercial product benzene are described in this section, no measures with regard to benzene as a natural constituent (e.g. of petrol) or as a combustion product.

According to Directive 2000/69/EC[9] a limit value of benzene in ambient air is set at 5 µg/m³.

Benzene is a highly volatile organic chemical (vapour pressure of 99.7 hPa at 20°C), i.e. it comes under the VOC Directive[10] (1999/13/EC) on the limitation of emissions of volatile organic compounds (VOC) due to the use of organic solvents in certain activities and installations. However, benzene is used in solvents in very small quantities only.

According to the NEC Directive [11](2001/81/EC) on national emission ceilings (NEC) for certain atmospheric pollutants Member States shall limit their annual national emissions of VOC to amounts not greater than the emission ceilings laid down in Annex I of the Directive by the year 2010 at the latest. The Directive provides for interim and long-term environmental objectives for ground-level ozone pollution, on which the necessary measures to reduce such pollution are to be based. Member States shall, by 2002, draw up programmes for the progressive reduction of national emissions with the aim of complying with the NECs by 2010. Member States shall prepare emission inventories and emission projections for 2010 and report annually to the Commission. In 2004 the Commission shall report to the European Parliament and the Council on progress on the implementation of the NECs and on the extent to which the interim and long-term environmental objectives are likely to be met.

In Directive 2002/3/EC relating to ozone in ambient air, long-term objectives, target values, alert thresholds and information thresholds for ozone concentrations in ambi-

[9] OJ L 313, December 13th, 2000, pp.12-21
[10] OJ L 85, March 29th, 1999, pp. 1-22
[11] OJ L 309, November 27th, 2001, pp. 22-30

ent air are fixed (Table 5). The long-term objectives mean an ozone concentration below which, according to current scientific knowledge, direct adverse effects on human health and/or the environment as a whole are unlikely. The target values have to be met in 2010. Alert thresholds are levels beyond which there is a risk to human health from brief exposure for the general population and at which immediate steps shall be taken by the Member States. The information threshold is a level beyond which there is a risk to human health from brief exposure for particularly sensitive sections of the population and at which up-to-date information is necessary. The Member States have to take appropriate risk reduction measures to meet the target values and long-term objectives set out in the Directive. Ozone and ozone precursor substances have to be monitored. Beside other substances it is recommended to measure benzene as an ozone precursor substance. Every year the annual average concentrations of the precursor substances have to be reported to the Commission.

Table 5: Ozone standards laid down in Directive 2002/3/EC:

Type of standard	Numerical value
Information threshold	180 µg/m³ (1 hour average)
Alert threshold	240 µg/m³ (1 hour average)
Target value	
- for the protection of human health	120 µg/m³ (max. daily 8h mean) not to be exceeded on > 25 d per calendar year averaged over 3 years
- for the protection of vegetation	18 000 µg/m³·h (AOT40*, calculated from 1 h values from May to July) averaged over 5 years
Long-term objective	
- for the protection of human health	120 µg/m³ (max. daily 8 h mean within a calendar year)
- for the protection of vegetation	6000 µg/m³·h (AOT40*, calculated from 1 h values from May to July)

* AOT40 means the sum of the difference between hourly concentrations greater than 80 µg/m³ (=40 ppb) and 80 µg/m³ over a given period using only the 1 h values measured between 8:00 and 20:00 Central European Time each day

3.4 Emissions to Water

The List of Priority Substances in the Field of Water Policy complying with the Water Framework Directive (2000/60/EC)[12] was compiled on the basis of the COMMPS procedure and includes benzene as a „priority substance“ (Dec. no. 2455/2001/EC). Under the Water Framework Directive (WFD), specific measures must be adopted at Community level against pollution of water by individual pollutants or groups of pollutants presenting a significant risk to or via the aquatic environment. In case of „priority substances“ such measures are aimed at the progressive reduction and in case of „priority hazardous substances“ at the cessation or phasing out of discharges, emissions and losses. The Expert Advisory Forum is responsible for the setting of Community-wide environmental quality standards (EQS) under the WFD. Based on the drinking water standard for benzene a water quality standard of 1 µg/l in inland waters as well as transitional, coastal and territorial waters is discussed in this forum.

[12] OJ L 327, December 22nd, 2000, pp. 1-21.

As a maximum allowable concentration (quality standard accounting for transient concentration peaks) 1.7 µg/l are proposed. However, it is currently discussed if a water quality standard of 1.7 µg/l would be sufficient for all surface waters, allowing for simple treatment before the water is used for human consumption. All the quality standards discussed are far below the $PNEC_{aqua}$ of 80 µg/l.

No “A1 value” for drinking water abstraction has been set in the context of Council Directive 75/440/EEC[13] concerning the quality required of surface water intended for the abstraction of drinking water. However, a standard of 1 µg benzene/l for the maximum acceptable concentration in drinking water is in place according to Council Directive 98/83/EC[14] on the quality of water intended for human consumption.

Council Directive 76/464/EEC[15] on pollution caused by certain dangerous substances discharged into the aquatic environment requires Member States to take the appropriate steps to eliminate pollution of the waters by the dangerous substances in the families and groups of substances in List I. In Article 3, the Directive stipulates that discharges into the waters of the European Community which are liable to contain a substance belonging to List I require prior authorization by the competent authority of the Member State concerned. The authorization shall lay down emission standards. In addition Member States are obliged to submit quality objectives for List I substances in waters.

The communication of the Commission of June 22, 1982 on hazardous substances which might be included in List I of 76/464/EEC[16] gives 129 priority substances or substance groups, amongst them benzene. In February 1983 the Council of Ministers stated that the Member States recognised the list as a provisional basis for national measures when applying the measures provided for in the Directive.[17]

European Court case law requires that at least 99 potential list I substances according to 76/464/EEC for which the Commission has so far not adopted limit values or environmental quality standards need to be considered as List II substances (France/Zabel 2001). For List II substances Member States are required to prepare pollution reduction programmes (Art. 7, 76/464/EEC). Amongst them is benzene. The existing national quality standards for benzene in surface waters are listed by Lepper (2002) as shown in Table 6.

The International Commission for the Protection of the Rhine (ICPR) has set a water quality target of 2 µg/l for the protection of aquatic communities from benzene in the river Rhine (Lepper, 2002). This quality target is not legally binding. The CSTEE recommends a water quality objective of 10 µg/l.

[13] OJ L 194, July 25th, 1975, pp. 26-31
[14] OJ L 330, December 5th, 1998, p. 32-54
[15] OJ L 129, May 18, 1976, pp. 23-29.
[16] OJ C 176, July 14, 1982, pp. 3-10.
[17] OJ C 46, February 2, 1983, p.17.

Table 6: Existing national quality standards for benzene in surface waters (Lepper, 2002)

State	national quality standard [µg/l]	comments
Bulgaria	500	
Czech Republic	10 50	water supply waters other surface waters refer to the 90-percentile of monitoring data
Denmark	2	statutory standard
France	5	indicator value for "very good quality" with regard to the potential to support biological function; refers to the 90-percentile of monitored concentrations; not legally binding
Germany	10	legally binding
Greece	10	refers to the mean value of the results determined during one year
Portugal	10	
Slovak Republic	10 10 50 1 50	class II (clean water) max. in surface water intended for drinking water prep. max. after discharging of waste waters drinking water admissible water pollution level (supposed to enter into force from 2002 on)
Spain	30	
The Netherlands	240	refers to the 90-percentile value from the benzene monitoring data (per location, per year); monitoring data standardized with regard to suspended matter
United Kingdom	30	statutory EQS

3.5 National Measures

According to the German ordinance on marketing and use restrictions for chemicals (Chemikalienverbots-Verordnung) benzene and preparations containing 0.1% (weight) or more benzene may generally not be marketed. However, exemptions are permitted, beside others (fuel, crude oil etc., export, education) for substances and preparations intended for the use in industrial processes in closed systems.

In the general administrative provisions to the Federal Immission Control Act - the German Technical Instruction on Air Quality (TA Luft from 24.07.2002) - benzene is classified into the emission class III of carcinogenic substances. As a minimum requirement the sum of these class III substances may not exceed a mass flow rate of 2.5 g/h and a mass concentration of 1 mg/m³ in industrial emissions. For several special types of installations different benzene emission values are established:

÷ installations for cyclohexane oxidation,
÷ facilities producing gas soot,
÷ cement furnaces,
÷ furnaces for burning ceramic products with no external post-combustion,
÷ foundries for non-ferrous metals,
÷ facilities for the production of carbon (woody lignite) or electro graphite by firing or graphitisation.

Further instructions are given with regard to facilities for storing combustible fluids, e.g. benzene.

The Slovak Republic issued emission limit values for benzene emissions to air. At new sources with a mass flow higher than 25 g/h, the total concentration of benzene in waste gas may not exceed the value of 5 mg/m³. At existing sources with a mass flow higher than 50 g/h, the total concentration of benzene in waste gas may not exceed the value of 5 mg/m³. From 1 January 2005 the emission limit for all sources (new and existing) with a mass flow higher than 25 g/h, the total concentration of benzene in waste gas may not exceed the value of 5 mg/m^3.

According to the German Wastewater Ordinance (October 23rd, 2002) benzene emission limit values are set for wastewater for several industrial sectors (Table 7).

Table 7: Limitation of benzene and its derivatives in the German Wastewater Ordinance

Appendix no.	**Industrial source**	**Limit of benzene and its derivatives in wastewater***
27	physico-chemical waste treatment, reconditioning of waste oil	1 mg/l **
28	paper and cardboard production	wastewater may not contain benzene from the application of organic solvents and detergents
32	processing of solid caoutchouc	0.1 mg/l **
36	production of hydrocarbons	0.05 mg/l **
46	coal coking	0.03 g/t **
54	production of semi-conductor components	0.05 mg/l **
56	production of printing blocks, publications and graphic-arts products	10 mg/l ***

* measured in qualified random sample or 2 h composite sample
**wastewater prior to blending
*** wastewater at the site of occurence

4. Possible Further Risk Reduction Measures and their Assessment

In this section possible further risk reduction measures shall be described for the risks identified in the RAR (draft of March 25, 2003):

- risks to industrial WWTPs at production and/or processing sites
- risks to the aquatic environment at production and/or processing sites
- risks to the atmosphere because of the contribution of benzene to the formation of tropospheric ozone.

However, recently adopted EU legislation as described in section 3 is already going to affect the risks to the aquatic environment and the atmosphere.

A benzene limit value for ambient air has been set. The provisions of the NEC-Directive with regard to VOCs and Directive 2002/3/EC relating to ozone in ambient air indirectly affect benzene emissions to air. BAT for benzene and/or VOC emissions to air from benzene production and processing sites is described in the relevant BREFs under the IPPC Directive. These measures are considered appropriate and sufficient for the protection of human health and the environment from tropospheric ozone, which is partly formed from benzene in the environment.

A Community-wide environmental quality standard for benzene in surface waters will be adopted under the Water Framework Directive. The numerical value will be well below the $PNEC_{aqua}$ of 0.08 mg/l. For the priority substances of the Water Framework Directive "the Commission shall submit proposals of controls for the progressive reduction of discharges, emissions and losses of the substances concerned. (…) In doing so it shall identify the appropriate (…) level and combination of product and process controls for both point and diffuse sources and take account of Community-wide uniform emission limit values for process controls." Therefore no further measures are necessary for the protection of surface waters from benzene. It should be ensured that emission limit values below the $PNEC_{microorganism}$ (1.3 mg/l) are going to be established. Thus the elimination of potential risks to industrial WWTPs could be achieved. This measure is considered as effective and practicable. Since there are probably only very few installations which actually have any benzene impacts on their WWTPs, the costs associated with this measure are considered to be low. In addition plant operators act for their own benefit when they optimise their WWTPs. The monitoring provisions of the WFD apply.

The IPPC Directive will also contribute to the reduction of benzene emissions. The BREF on mineral oil and gas refineries gives a benzene concentration range which should be achieved when using BAT in this sector. The BREF on iron and steel production mentions concentrations of several parameters which should be achieved when using BAT. To demonstrate the functioning of the WWTPs the concentrations cited in the BREFs have to be met. However, the BREF on large volume organic chemicals does not mention any benchmarks for concentrations of benzene and/or other parameters in the WWTP effluents.

The risk to industrial WWTPs could be limited by process-integrated measures or by installation of a wet air oxidation or a stripping facility prior to the biological wastewater treatment. To some extent this is already reflected in the LVOC BREF. However, BAT for benzene in wastewater is described only for production of BTX and ethylbenzene, not for the production of cumene and maleic anhydride from benzene. Production of further benzene secondary products is not mentioned at all. In the horizontal BREF for the chemical sector adequate techniques for benzene reduction in wastewater are introduced. However, according to the BREF the benzene concentration considered as inhibiting for nitrogen elimination in biological WWTPs is two orders of magnitude higher than the $PNEC_{microorganism}$. In summary it is difficult to predict the implications of the IPPC Directive.

Emission reduction measures under IPPC can only be supplementary measures, because

- IPPC pursues an integrated approach, i.e. the aim is to minimise the total environmental impact of an installation. The BREFs comprise various approaches to achieve BAT and the reductions of impacts on the environment achieved by the different techniques are weighed against each other.
- IPPC focuses on sum parameters. The establishment of EU-wide emission limit values for single substances under IPPC is not supported by the Commission (see communication of the Commission of 19.06.2003).
- the contents of the BREFs are not binding for the Member States. The method of implementation at Member State level varies, i.e. the actual implementation of BAT at the industrial installations depends on the engagement of the respective Member States and/or the local permitting authorities.
- the structure of the BREFs does not always provide for the inclusion of information on specific substances, e.g. the LVOC BREF provides generic information and detailed information on some selected ‘illustrative processes’.
- emission limit values based on BAT and taking into account technical conditions of the individual installations may be set by permitting authorities, but only “representative values” (no extremes) have to be reported to the COM for some specific installations and substances. Benzene emissions to water have to be reported as BTEX (sum of benzene, toluene, ethylbenzene, xylene).

However, the results of the benzene risk assessment and potential risk reduction measures should be reflected in the BREF on large volume organic chemicals as far as possible. They could be taken into account in the next revision of the BREF. The difference between the benzene concentrations considered as inhibiting for biological WWTPs in the horizontal BREF and the RAR should be investigated.

Existing national laws could be used to reduce effects of benzene on surface waters and industrial wastewater treatment plants before EU-wide measures have an impact.

5. Further Risk Reduction Measures Recommended

As pointed out in section 4 existing Community legislation is considered appropriate and sufficient for the protection of the environment from benzene emissions to surface waters and from tropospheric ozone, which is partly formed from benzene in the environment.

Based on the considerations in section 4 the following risk reduction measures are recommended for the elimination of potential risks to industrial wastewater treatment plants at benzene production and processing sites:

- Under the Water Framework Directive it should be ensured that emission limit values below the $PNEC_{microorganism}$ (1.3 mg/l) are established.
  [However, this recommendation has been deleted after discussions at the Risk Reduction Meeting. At industrial WWTPs benzene removal is carried out by an adapted biological system. It is in the interest of the companies not to overload their system. Implementation of BAT is considered to be sufficient for risk reduction.]

- The results of the benzene risk assessment and potential emission reduction measures for benzene should be taken into account under the IPPC Directive in the next revision of the BREF on large volume organic chemicals and if necessary in the horizontal BREF on the chemical sector.

- With intent to accelerate the implementation of emission reduction measures existing national laws could be used to reduce effects of benzene on industrial wastewater treatment plants before EU-wide measures have an impact.

6. Possible Monitoring Arrangements

With regard to an EU-wide EQS for benzene the Water Framework Directive includes monitoring provisions. Monitoring of ELVs should be performed by the polluters in the effluents of the respective point sources.

7. Organisations consulted

none

8. References

European Commission (2001): Best Available Techniques Reference Document on the Production of Iron and Steel, December 2001

European Commission (2002): Reference Document on Best Available Techniques in the Large Volume Organic Chemical Industry, February 2002

European Commission (2003a): Reference Document on Best Available Techniques for Mineral Oil and Gas Refineries, February 2003

European Commission (2003b): Reference Document on Best Available Techniques in Common Waste Water and Waste Gas Treatment/Management Systems in the Chemical Sector, February 2003

France, Zabel (2001): Assessment of Programmes under Article 7 of Directive 76/464/EEC,http://europa.eu.int/comm/environment/water/water-dangersub/article7ofdirective77464eec.pdf

Lepper (2002): Towards the Derivation of Quality Standards for Priority Substances in the Context of the Water Framework Directive (Final report prepared for the Commission)