TC NES SUBGROUP ON IDENTIFICATION OF PBT AND VPVB SUBSTANCES

RESULTS OF THE EVALUATION OF THE PBT/VPVB PROPERTIES OF:

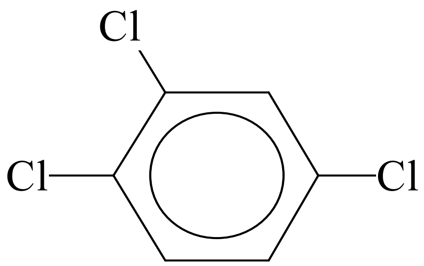
Substance name: 1,2,4-trichlorobenzene

EC number: 204-428-0

CAS number: 120-82-1

Molecular formula: C6H3Cl3

Structural formula:



Summary of the evaluation:

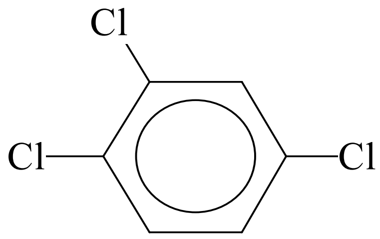
The available screening test data and the few half-life data at environmentally more realistic conditions suggest that 1,2,4-trichlorobenzene should be considered to fulfil the P –criteria but not the vP criteria. The substance just fulfils the B -criterion but it does not fulfil the T –criterion, although the lowest aquatic NOECs are not very far from the cut-off value. As 1,2,4-trichlorobenzene in addition has a very high potential for long-range transport via air, it should be considered as a PBT-substance. Further information is unlikely to change the conclusion.

Reference is made in general to the adopted EU RAR (European Commission, 2003) and in relation to biodegradation to a few specifically here mentioned references, which were identified after the RAR adoption.

JUSTIFICATION

1 IDENTIFICATION OF THE SUBSTANCE AND PHYSICAL AND CHEMICAL PROPERTIES

Name:	1,2,4-trichlorobenzene
EC Number:	204-428-0
CAS Number:	120-82-1
IUPAC Name:	1,2,4-trichlorobenzene
Molecular Formula:	$C_6 H_3 Cl_3$
Structural Formula:	



Molecular Weight:	181.46
Synonyms:	1,2,4-TCB (abbreviation), 1,2,4-trichlorbenzol, 1,2,5-trichlorobenzene, 1,3,4-trichlorobenzene

1.1 PURITY/IMPURITIES/ADDITIVES

Information from manufacturers (one or more of mentioned below):

Total tetrachlorobenzenes, ≤ 0.2% w/w

1,2,3-trichlorobenzene < 1% w/w (usually 0.1-0.4%)

1,3,5-trichlorobenzene < 2 % w/w

1,2-dichlorobenzene < 0.25

1,4-dichlorobenzene < 0.25%

Dichlorotoluenes < 0.2%

2/4-bromo-chlorobenzenes < 0.15%

1.2 PHYSICO-CHEMICAL PROPERTIES

Table 1 Summary of physico-chemical properties. For details and references, see European Commission (2003). Only the values used for exposure estimation of the risk assessment are provided below

REACH ref Annex, §	Property	Value	Comments
V, 5.1	Physical state at 20 C and 101.3 KPa	Liquid	
V, 5.2	Melting / freezing point	16 - 17°C	Merck Index (1996), BUA (1987), Weast (1975)
V, 5.3	Boiling point	213.5°C at 1,013 hPa	Weast (1975)
V, 5.5	Vapour pressure	36 Pa at 20°C	Bayer (1994)
V, 5.7	Water solubility	36 mg/l at 20°C	BUA (1987), Bayer (1986)
V, 5.8	Partition coefficient n-octanol/water (log value)	log Kow: 4.05	Bruijn et al. (1989)
VII, 5.19	Dissociation constant	-	

2 MANUFACTURE AND USES

According to industry, 1,2,4-trichlorobenzene is at the present produced in the EU-15 by one producer only in a volume of approximately 3,000 tonnes/annum and used solely as an intermediate by a limited number of customers for the manufacture of chlorinated pesticides and higher chlorinated benzenes. The present market volume is not known.

According to the EU risk assessment of 1,2,4-trichlorobenzene (European Commission, 2003), the EU-15 production volume in 1994/1995 was 7,000 tonnes/annum, import 2,000 tonnes/annum, export 7,600 tonnes/annum and the use volume 1,400 tonnes/annum. The production has ceased steadily in the Western Europe within the last two decades from 17,000 tonnes/annum in the year 1983.

Following uses have been identified which have been to date stopped by voluntary action or still occur as minor uses:

process solvent in industry

dye carrier in textile industry

cooling agent and lubricant in metal industry

additive in polish and maintenance products

corrosion inhibitor

additive in high performance insulation of wire and cable products

blend in the production of a brightener solution for use in lead/tin plating baths

An isomer mixture of trichlorobenzenes was used formerly as additive in dielectric fluids in connection with the use of PCBs in electrical equipment. This use has ceased in Europe. The volume contained in the old electrical equipment still in use has been estimated at 5,000 tonnes for the EU-15. Several other former uses have been identified, but they do not have relevance for the present.

3 CLASSIFICATION AND LABELLING

Classification and labelling according to the 28th ATP of the Directive 67/548/EEC:

CLASSIFICATION

Xn; R22	Harmful if swallowed
Xi; R38	Irritating to skin
N; R50-53	Very toxic to aquatic organisms. May cause long-term adverse effects in the aquatic environment

Specific concentration limits: None

LABELLING

Xn; N

R: 22-38-50/53

S: (2-)23-37/39-60-61

4 ENVIRONMENTAL FATE PROPERTIES

4.1 DEGRADATION (P)

4.1.1 Abiotic degradation

Based on experimental data on hydrolysis at 50°C, 1,2,4-trichlorobenzene (1,2,4-TCB) is not expected to hydrolyse under normal environmental conditions.

Degradation by direct photolysis is not expected to be essential because the maximum absorption value is 286 nm. Experimental data obtained close to environmental conditions confirm that photolysis in water is slow. Even though direct photolysis in water under some artificial laboratory conditions may be fast, it is estimated that direct photolysis under environmental default situations will be slow due to the attenuation of light intensity by water itself, dissolved and particulate organic matter and inorganic matter.

Photodegradation in water may result in formation of the degradation products 1,3- and 1,4-dichlorobenzenes, 1,4-dichlorophenol and 4-chlorophenol. In addition, one photolysis study conducted in artificial conditions with nitrate addition indicates that water quality may indirectly have impact on the photolysis rate.

Half-lives of 18.5 and 30.2 days, respectively, were derived in two studies for photochemical oxidation in atmosphere. In addition, a calculated half-life of 38 days has been obtained (AOPWIN).

4.1.2 Biotic degradation

On the basis of three available laboratory biodegradation screening tests, 1,2,4-TCB is not readily biodegradable but biodegradation occurs in conditions favouring biodegradation (using adapted sludge or additional carbon source). In addition, 1,2,4-TCB can be degraded by adapted STP sludge according to a study monitoring the fate of ^{14}C-labelled 1,2,4-TCB.

In a mesocosm study with seawater, degradation of 1,2,4-TCB was observed to have a minor importance to the mass balance of the substance. For sediment, anaerobic degradation half-lives > 200 days have been measured along with formation of di- and monochlorobenzenes indicating reductive dechlorination to be the degradation route. In available soil biodegradation studies a very low mineralisation rate (0.075 to approximately 0.15% d^{-1}) for aerobic conditions was observed. Anaerobic conditions were observed in one study to decrease the rate of mineralisation.

In addition to the experiments reviewed in the European Commission (2003), two other biodegradation studies are available. Bartholomew and Pfaender (1983) and Pfaender and Bartholomew (1982) conducted simulation type of tests measuring mineralisation ($^{14}CO_2$ respiration) and uptake of ^{14}C labelled metabolites. Kinetic values for the total biodegradation of 1,2,4-TCB covering both incorporation of ^{14}C into biomass and $^{14}CO_2$ -production, are illustrated in **Table 4.1**. The tests have also been reviewed by Battersby (1990).

Table 4.1 Biodegradation rates for 1,2,4-trichlorobenzene as derived by Bartholmew and Pfaender (1982) and the corresponding half-lives

Site	Date	Temperature (°C)	$V_{max}/K_m = k_1$ (d^{-1}) [1]	T½ (d)
River, upstream	7 Nov. 80	12	0.029	23.9
River, upstream	26 May 81	24	b.d. [2]	-
Estuary	7 Nov. 80	14	b.d. [2]	-
Estuary	26 May 81	28	0.027	25.7
Marine	7 Nov. 80	17	b.d. [2]	-
Marine	26 May 81	24	0.012	57.8

1) Original data from Bartholomew and Pfaender (1982); calculations similar to those in Battersby (1990)
2) b.d., below detection limit (V_{max} was less than 1 ng liter^{-1} h^{-1} and less than the metabolic rate that could be detected by the experimental method)

The data in Table 4.1 indicate that 1,2,4-TCB is degraded under some conditions with half-lives of approx. 25 days in fresh and estuarine waters and below 60 days in marine water. However, biodegradation rates were too low to be determined in half of the experiments. No explanation for the different results was provided by the authors. The $^{14}CO_2$ production was reported to be very low in general (no values provided by the authors), which implies that the ^{14}C incorporated by the biomass consisted of metabolites that were not further degraded during the experiment. It is considered, that the results of these two experiments do not change the overall picture provided by the other simulation type of studies available.

The available QSAR –estimations support the test data.

4.1.3 Other information [1]

4.1.4 Summary and discussion of persistence

1,2,4-TCB has a low degradation rate in the atmosphere (DT50 is between 18.5 and 38 days). It is not expected to undergo abiotic degradation in water, sediment or soil, but it can be considered as inherently biodegradable. The default biodegradation half-lives of 150 days for surface water and

[1] For example, half life from field studies or monitoring data

300 days for soil and sediment as provided by the Technical Guidance Document for inherently biodegradable substances were used in the quantitative PEC – calculations of the EU risk assessment.

Additional biodegradation simulation test data could be useful for modelling purposes to give more accurate information on the biodegradation rates, but it is unlikely that the results would change the conclusion.

4.2 ENVIRONMENTAL DISTRIBUTION

4.2.1 Adsorption

1,2,4-TCB has a high adsorption potential and the mobility in soil is expected to be low. Based on several experiments and model estimates, a K_{oc} of 1,400 has been estimated. Due to the slow degradation in soil, 1,2,4-TCB may, however, leach through sandy soils with low organic carbon content and reach groundwater.

4.2.2 Volatilisation

Vapour pressure of 1,2,4-TCB is 36 Pa (at 20°C) and the substance can be classified generally as volatile. A Henry's Law constant of 181 Pa m^3 mol^{-1} has been calculated from a water solubility of 36 mg l^{-1} and the vapour pressure above. Other modelled and experimentally derived values are also above 100 Pa m^3 mol^{-1}, which indicate high volatility from water surface. Due to a high adsorption potential to organic matter, volatilisation from soil and sludge is lower.

4.2.3 Long-range environmental transport

Atmosphere is the main distribution route of 1,2,4-TCB according to the available distribution model calculations using MacKay Level I and EQC models. Atmospheric half-life of more than 2 days and vapour pressure < 1,000 Pa are used as the screening criteria for long-range atmospheric transport potential in the Stockholm Convention and in the POP-Protocol of the UNECE LRTAP-Convention. For 1,2,4-TCB, atmospheric residence half-lives of 547 hours over land, 349 hours over sea and 428 hours in total have been estimated. In addition, a calculated travelling distance of 7,717 km (where 50% of substance is still airborne with a wind speed of 5 m s^{-1}) indicates very high potential to long-range atmospheric transport.

4.3 BIOACCUMULATION (B)

4.3.1 Screening data[2]

On the basis of octanol-water partitioning (logKow is approximately 4), moderate to high bioaccumulation potential is expected. QSAR estimates from three models gave BCFs between 250 and 600.

4.3.2 Measured bioaccumulation data[3]

Following plausible experimental values for bioconcentration in fish are available for 1,2,4-TCB.

Table 4.2 Reliable experimental bioconcentration factors for fish. For details and references, see European Commission (2003)

Fish species	Exposure concentration (mg l^{-1})	Exposure time (d)	BCF (whole body)	Reference
Salmo gairdneri	0.0000032	119	1,300	Oliver and Niimi (1983)
Salmo gairdneri	0.000052	105	3,200	Oliver and Niimi (1983)
Cyprinus carpio	0.005	42	120-1,320	MITI (1992)
Cyprinus carpio	0.05	42	420-1,140	MITI (1992)
Jordanella floridae	0.0038	28	2,026	Smith et al. (1990)
Leiostomus xanthurus	0.010	28	135	Heitmüller and Clark (1989)
Brachydanio rerio	0.0085	28	1,412	Ballhorn et al. (1984)
Brachydanio rerio	0.1129	28	865	Ballhorn et al. (1984)
Brachydanio rerio	0.1709	28	683	Ballhorn et al. (1984)
Brachydanio rerio	0.2141	28	574	Ballhorn et al. (1984)
Cyprinus carpio	0.004		830	Broecker et al. (1984)
Cyprinus carpio	0.04		805	Broecker et al. (1984)
Poecilia reticulata	0.136	17	1,139	Eck et al. (1997)

In addition, whole body BAFs[4] have been estimated from field bioaccumulation factors (C_{fish}/C_{water} measured in the field) for three fish species (*Fundulus heteroclitus*, BAF of 2,395; *Micropoganias undulatus*, BAF of 1,810; and *Brevoortia patronus*, BAF of 3,620).

The test data on other organisms (daphnids, shrimp, plankton algae) suggest lower bioaccumulation than in fish (BCF 69-250) but generally such data are difficult to use in relation to the PBT assessment and in particular the data on 1,2,4-TCB are not regarded as highly reliable. For example, for algae data no differentiation is made in the experiments between bioaccumulation and sorption to the cell surfaces/membrane.

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[2] For example, log K_{ow} values, predicted BCFs

[3] For example, fish bioconcentration factor

[4] Cfish/Cwater but including exposure both via water and food

4.3.3 Other supporting information[5]

Measured data on concentrations of 1,2,4-TCB in aquatic organisms available mainly from the 1980's have been reviewed in the EU risk assessment of 1,2,4-TCB (European Commission, 2003). 1,2,4-TCB was found in herring gull (*Larus argentatus*) eggs in the average of 0.02 ± 0.02 mg kg^{-1} wwt. The eggs were collected around Great Lakes in Canada during 1978-1982. A comparison of concentrations in marine fish species measured in Slovenia and Japan coastal waters with the available measured concentrations in seawater would seem to be in agreement with the experimental BCF-values.

4.3.4 Summary and discussion of bioaccumulation

Experimental bioconcentration factors for fish range from 120 to 3,200, depending on the species, exposure time and exposure concentration. Supported by the high bioaccumulation factors derived from field bioaccumulation data and the few monitoring data from biota give reason to judge 1,2,4-TCB as a substance with high bioaccumulation potential. A BCF of 2,000 has been used as a realistic worst case estimate in the EU risk assessment (European Commission, 2003).

5 HUMAN HEALTH HAZARD ASSESSMENT

5.1 MAMMALIAN TOXICITY

Chronic toxicity: 1,2,4-TCB has been extensively investigated in long-term mammalian studies, including life time studies. Based on the available information it is concluded that the target organs are the liver and kidney and that the NOAEL is 6 mg/kg bw/day (rat 2-year study). However the severity of the observed effects was not sufficient to call for a classification, Xn, R48.

Mutagenicity and carcinogenicity: Based on the available information the overall conclusion of the EU risk assessment was that, even though some indications are present, they do not warrant classification for mutagenicity or carcinogenicity.

Reproductive toxicity. The data present do not indicate that classification for reproductive effects is necessary. However, the available studies suffer from various deficiencies for establishment of NOAEL or LOAEL and it could not be concluded that reproductive effects do not occur at dose levels also causing overt maternal toxicity. In spite of this it was not considered necessary to require further testing on reproductive effects in the quantitative EU risk assessment, because the use of the NOAEL of 6 mg/kg bw/day for chronic toxicity was also considered to cover possible concern for reproductive toxicity.

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[5] For example, measured concentrations in biota

6 ENVIRONMENTAL HAZARD ASSESSMENT

6.1 AQUATIC COMPARTMENT (INCLUDING SEDIMENT)

6.1.1 Toxicity test results

1,2,4-TCB causes non-specific narcotic effects. Due to its volatility and photolysis in conditions where ecotoxicity tests are conducted, static tests may underestimate the toxicity especially if open test systems are used and no monitoring of test concentrations has occurred.

6.1.1.1 Fish

Acute toxicity

Valid data on acute toxicity to fish are available from eleven studies. The LC_{50}-values are between 0.7 and 12.3 mg l^{-1}.

Long-term toxicity

Valid studies on long-term toxicity to fish are available for five fish species (see Table 5). All results are based on measured concentrations.

Table 5 Valid data on long-term ecotoxicity to fish. For details and references, see European Commission (2003)

Species	Duration	EC_{50} mg l^{-1}	NOEC mg l^{-1}	Method, conditions	Reference
Pimephales promelas	32 days		0.29	Flow-through, ESF-test	US EPA (1985), McCarty et al. (1985) A
Pimephales promelas	32 days		0.50	Lake water, flow-through, ESF-test, EPA	Carlson and Kosian (1987)
Brachydanio rerio	21 days	2.4	0.04	Flow-through, mortality, behaviour	Broecker et al. (1984)
Salmo gairdneri	85 days		0.13	ELS (fry)	Carlson and Kosian (1987)
Poecilia reticulate	14 days		0.11	Semi-static (daily renewal), growth	Könemann (1981)
Cyprinodon variegatus	-			ESF-test, MATC = 0.222 mg l^{-1}	Suter and Rosen (1988)

Abbreviations: ESF-test (Egg and Sac Fry) embryo-larvae test. ELS: Early Life Stage test

6.1.1.2 Aquatic invertebrates

Acute toxicity

Acute toxicity data from eleven valid tests on invertebrates are available for *Daphnia magna*, *Orconectes immunis* (greyfish), *Palaemonetes pugio* (grass shrimp), *Mysidopsis bahia* (mysid shrimp) and *Nitorca spinipes* (copepod). The $L(E)C_{50}$ values from these tests are between 0.45 and 3.39 mg l^{-1}.

Long-term toxicity

Valid studies on long-term toxicity to invertebrates are available for *Daphnia magna* and *Mysidopsis bahia* (see Table 6). Results of *Daphnia magna* are based on measured concentrations.

Table 6 Valid data on long-term toxicity to aquatic invertebrates. For details and references, see European Commission (2003)

Species	Duration	EC_{50} (mg l^{-1})	NOEC (mg l^{-1})	Method, conditions	Reference
Daphnia magna	14 days	0.45	(0.32)	Semi-static, (closed)	Calamari et al. (1983) (NOEC = EC16)
Daphnia magna	16 days	0.32 *	0.19 *	Semi-static (3 times a week); mortality	Hermens et al. (1984)
Daphnia magna	16 days	0.16 *	0.06 *	Semi-static (3 times a week); reproduction	Hermens et al. (1984)
Daphnia magna	21 days		0.4	Semi-static, EEC-Ann.V-c; reproduction	Broecker et al. (1984)
Daphnia magna	28 days		0.36	Semi-static (closed), ASTM 1980	Richter et al. (1983)
Mysidopsis bahia	28 days		≤0.064	Flow-through, measured, EPA standard	US EPA (1988) (LOEC = 0.033 mg l^{-1})

* EC_{50} –values and NOECs are corrected values of the Rapporteur.

6.1.1.3 Algae and aquatic plants

Results of four standard ecotoxicity tests on algae are available. However, one test only was conducted in a closed system giving an EC_{50} of 1.4 mg l^{-1}. In the tests with open systems EC_{50}-values were higher but probably underestimates, while volatilisation was not accounted for.

6.1.2 Sediment organisms

Two studies have looked at the effects of 1,2,4-TCB on benthos. In an 8-week study employing macrobenthos community and spiked sediment, the lowest concentration influencing the number of animals was 100 mg kg^{-1} sand (ww) (added 1,2,4-TCB, nominal) for molluscs, echinoderms and the most abundant arthropod *Corophium acherusicum* corresponding to 6 mg kg^{-1} measured at the end of exposure. In the same study planctonic larvae of macrobenthos were exposed 6 days to 1,2,4-TCB via water under flow-through conditions. The lowest effect concentration (mortality) of 0.04 mg l^{-1} was observed for mollusc larvae. In another study, grass shrimp (*Palaemonetes pugio)* and amphioxus (*Branchiostoma caribaeum*) were tested via water and sediment exposure, respectively. During a 10-day sediment exposure, no mortality was observed for grass shrimp at 10 mg kg^{-1}sand (wet weight). For amphioxus LC_{50} was observed to be 200 mg kg^{-1} sand (ww) and NOEC 75 mg kg^{-1} sand (ww).

6.1.3 Other aquatic organisms

Results from ecotoxicity tests with *Tetrahymena poryformis* (protozoa), *Tanytarsus dissimilis* (chironomid) and *Aplexa hypnorum* (snail) gave EC_{50} values between 0.91-3.16 mg l^{-1}.

6.2 TERRESTRIAL COMPARTMENT

Ecotoxicity of 1,2,4-TCB to earthworms has been studied with four species with a study duration of 14 and 28 days. EC_{50} -values in the tests were 127-251 mg kg^{-1} dw in EEC artificial soil (with 10% peat, 20% clay and a pH of 6). EC_{50} –values from plant ecotoxicity tests with oats, turnip and lettuce were 48 –240 mg kg^{-1} dw. A 24-hour respiration inhibition test using sandy loam resulted an EC_{50} of 50 mg kg^{-1} dw. In addition, an EC_{50} of 18.3 mg l^{-1} has been obtained for *Pseudomonas fluorescens* in a bioluminescence test.

6.3 ATMOSPHERIC COMPARTMENT

No ecotoxicity data on exposure of plants via air are available.

7 PBT AND VPVB

7.1 PBT, VPVB ASSESSMENT

Persistence: 1,2,4-trichlorobenzene (1,2,4-TCB) is not subject to hydrolysis and its degradation half-life in air is ca. 30 days. The screening biodegradation tests indicate that 1,2,4-TCB is not readily biodegradable but is estimated to be inherently biodegradable.

Based on data from more environmentally relevant soil and sediment degradation tests half-lives of more than 200 days have been estimated.

A review (Battersby, 1990) and two articles to which reference is given (Pfaender and Bartholomew, 1982; Bartholomew and Pfaender, 1983) have in particular been evaluated by the PBT subgroup, because these references were not identified and evaluated during the discussion and completion of the EU risk assessment report. The review indicates that the degradation half-lives in fresh, estuary and marine water seem to be just below the trigger for P assignment. However, from the two original publications it appears that these half-lives were only observed in three out of six cases, whereas in the three other cases much lower degradation rates were observed. Furthermore, it was indicated by the authors of the studies that 1,2,4-TCB was not mineralised but either only taken up by the bacteria with no subsequent degradation, or altered to degradation products by co-metabolism.

Thus considering all data available, 1,2,4-TCB is concluded to fulfil the P-criterion but probably not the vP criterion. Biodegradation simulation tests could provide more information for the estimation of the degradation rates in the environment, but it is unlikely that further testing would change the conclusion.

Bioaccumulation: Reliable bioconcentration factors in the range of 120-3,200 are available from laboratory tests with fish. The field bioaccumulation data indicated higher bioconcentration factors than laboratory tests. Based on weight of evidence and employing the realistic worst case approach it is based on the available data concluded that 1,2,4-TCB fulfils the B-criterion but not the vB criterion.

Toxicity: Aquatic ecotoxicity tests with long-term exposure are available for crustaceans and fish. The lowest NOEC is 0.04 mg l^{-1} for zebra fish. Two NOECs in the same order of magnitude have been measured for crustaceans and all other NOECs are in the range of 0.1-0.5 mg l^{-1}. Therefore it is concluded that 1,2,4-TCB does not fulfil the T-criterion although the lowest NOECs are not very far from the T- cut off -value.

Other supporting information: Due to its volatility and persistence to atmospheric degradation, 1,2,4-TCB has a very high potential for long-range atmospheric transport. The estimated atmospheric residence life is 428 hours and estimated travelling distances are several thousand kilometres.

Summary:

It is concluded that the substance based on existing data should be regarded as a substance fulfilling the PBT-criteria and controlled as such. The substance is considered to fulfil the P criteria, but most probably not the vP-criteria. It is recognised, that 1,2,4-trichlorobenzene is a borderline case with regard to the B criterion and that it does not meet the T-criterion, although some aquatic toxicity data are not very far from the cut-off value, and some uncertainty still remains regarding mammalian toxicity. The overall conclusion (PBT) is however drawn taking supporting evidence into account relating to the very high long-range environmental transport potential of this substance.

INFORMATION ON USE AND EXPOSURE

Following the conclusions of the EU risk assessment, the strategy for limiting risks (European Commission, 2004) recommended:

" to consider marketing and use restrictions at Community level in Council Directive 76/769/EEC for all uses of TCB except as an intermediate to protect the environment and to reduce the indirect exposure via the environment. Where appropriate, marketing and use restrictions of articles containing TCB should also be considered."

It is noted that the risks identified in the EU risk assessment report and the proposed risk reduction measures are in general adequate to limit the environmental emission in the EU related to the current production and use of the chemical and therefore also adequately address the PBT – properties of the substance.

OTHER INFORMATION

The source of data in this document is the risk assessment of 1,2,4-trichlorobenzene (European Commission, 2003) unless separately stated.

Other sources:

European Commission (2004) Commission Recommendation of 29 April 2004 on the results of the risk evaluation and the risk reduction strategies for the substances: Acetonitrile; Acrylamide; Acrylonitrile; Acrylic acid; Butadiene; Hydrogen fluoride; Hydrogen peroxide; Methacrylic acid; Methyl methacrylate; Toluene; Trichlorobenzene (2004/394/EC). Official Journal of the European Union, L 144/72 EN, 30.4.2004.

European Commission (2003) European Union Risk Assessment Report, Vol. 26, 1,2,4-trichlorobenzene, CAS No: 120-82-1, EINECS No: 204-428-0. Publication EUR 20540 EN.

Bartholomew GW and. Pfaender FK (1983) Appl. Environ. Microbiol., 45: 103-109.

Battersby NS (1990) Chemosphere, 21: 1243-1284.

Pfaender FK and Bartholomew GW (1982) Appl. Environ. Microbiol., 44: 159-164.