Exploration of management options

for

Pentachlorophenol (PCP)

Paper for the 8 th meeting of the UNECE CLRTAP Task Force on Persistent Organic Pollutants, Montreal, 18 -20 May 2010

Colophon

By	Annemiek van der Zande NL Agency, The Netherlands
For	VROM, the Ministry of Environment

Date	22 March 2010
Reference	Draft document

Table of Contents

Executive summary

Pentachlorophenol (C_6Cl_5OH) is an aromatic hydrocarbon of the chlorophenol family. Pentachlorophenol, abbreviated to PCP, is registered with CAS number 87-86-5.

PCP was first introduced for use as wood preservative in the 1930's. Since it's introduction PCP has had a variety of other applications. Within the UN-ECE region it was widely used as biocide, pesticide, disinfectant, defoliant, anti-sapstain agent, anti-microbial agent and wood preservative. Wood preservation was by far the major application. The salt sodium pentachlorophenate (Na-PCP) was used for similar purposes as PCP and readily degrades to PCP. The ester pentachlorophenyl laurate (PCPL) was used in textiles. Na-PCP is registered with CAS number 131-52-2, PCPL with CAS number 3772-94-9. The environmental behaviour of all three substances are quite similar.
In the UN-ECE region PCP nowadays is solely used as wood preservative in the industrial market.

Production, use and emissions

As far as can be concluded from the information gathered, in the UN-ECE region there is one company manufacturing PCP, located in the U.S. The production volume in 2009 was indicated at 7,257 tonnes, which was marketed to the US, Canada and Mexico for wood preservation. In Europe and in Canada production stopped years ago.

PCP is one of the three major wood preservatives used in the industrial market in North America. The other two are chromated copper arsenate (CCA) and creosote. The majority of PCP used in North America is for treatment of poles: utility poles and cross-arms account for more than 90% of PCP-consumption. The total amount used in Canada is estimated at 150 tonnes, whereas U.S. consumption is estimated to be much higher: 5,000 tonnes in 2002. PCPL is no longer used in the UN-ECE region. Na-PCP is only used for wood preservation, like PCP.

Commercial PCP contains microcontaminants. Those of great concern are the dioxins, furans and hexachlorobenzene. When PCP is produced, used, and when PCP-articles are used or disposed of as waste, PCP and its microcontaminants are released into the environment.
Wood preservation and hazardous waste handling are the most important sources of PCP-emissions. In the U.S. approximately 2,600 kg PCP was released in 2008, of which 172 kg was released to air, 513 kg to water and 1,865 kg was land filled.

Management options and cost implications

Production and use
Production and consumption levels of PCP have decreased over the years. However, the relatively large volumes of PCP-treated poles in use are a matter of concern for the environment. In service as well as in the waste phase treated wood poles leach PCP and microcontaminants to the environment. When PCP-consumption is not phased out, these hidden reservoirs remain contaminating the environment. Guidelines for proper handling, use and disposal of wood poles are developed by USWAG. This will contribute to some part to emission reduction, but end users have no obligation to comply with these guidelines. Additional actions are required to phase out production and consumption of PCP. It is suggested to ban Na-PCP and PCPL as well, since these substances are closely related to PCP.

For the use as wood preservative alternative chemicals as well as alternate materials are generally available and applicable. Which alternative performs comparably to PCP, varies upon the type of product and type of application. None of the applications of preserved wood known is completely dependant on PCP, as reported by EPA. Although some of the alternative chemicals are more or less as toxic as PCP, like creosote, they do not contain the persistent microcontaminants that characterize formulated PCP products. The environment benefits even more from replacement of wood by materials like concrete, steel and fibre reinforced composite. To people who are frequently exposed to PCP-treated wood, like electrical utility linemen health risks reduce when other chemicals or alternate materials are used.

Unintentional emissions from waste handling
Wood poles treated with PCP or Na-PCP are hazardous waste. In the waste phase they should be treated as such. After service life they are either incinerated, disposed of in landfills, reused or recycled. Once land filled, treated poles still leach PCP and micro-contaminants into the environment. Therefore, incineration under controlled conditions is preferred over disposal into landfills.
The measures to control emissions of dioxins, furans and HCB from waste incineration are already covered in the guidance document on BAT (Annex V) of the POP-protocol. These techniques will be effective for PCP as well. Other management options concerning waste handling can be addressed in the guidance document on BAT also.

Costs of eliminating production and use
The sole producer of PCP is likely to be affected significantly by any restriction of PCP in the poles market. The company's sales of PCP in 2009 were $26.2 million. However, producers of potential alternatives to PCP would likely benefit from any restriction of PCP and would experience an increase in sales as a result.

The existing electrical transmission and distribution system in the U.S. and Canada is mainly supported by wood poles, of which about half still is treated with PCP. A ban on PCP will have major environmental benefits, but no doubtfully will have an impact on the industry involved as well. PCP wood preservation companies will have to shift capacity from PCP-treatment to other treatments. The preservation plants will have to upgrade equipment to accept new formulations. Data on quantitative costs are not available.
Because PCP has a small share in the lumber and timber market, the impact of a PCP-ban will not be so high as in the pole market.

No current applications other than wood preservation are found in the UN-ECE region. A ban on the use for applications other than wood preservation is therefore expected to have a negligible impact.
The use of PCPL has been banned in the UN-ECE region. Like PCP, Na-PCP is only used for wood preservation.

Costs of controlling unintentional emissions from waste handling
Since these measures are already part of the guidance document on BAT, no additional costs are expected for industry.

Costs for consumers
On a short term end users may experience fluctuating prices due to production shortages that may come from the transition of PCP-treated wood to alternatives.
Consumers in the end will experience only a small impact since most alternatives are available at reasonable costs. Price levels of wood poles treated with other chemicals are about the same as that of PCP-treated poles. Alternate materials like concrete, steel and fibre reinforced composite however are more expensive. Price increases are likely, but consumers may prevail the non-toxicity and durability over additional costs.

Costs for state budgets
The costs of a ban on PCP for the EU members states are zero, since a ban already is implemented in the EU. The costs for Canada and the U.S. are more difficult to estimate. There may be costs involved with adopted control measures, monitoring and

communication. These costs can be compensated using charges or taxes to stimulate the phase out process. Furthermore, replacing wood poles by alternate materials will considerably reduce the annual volumes of hazardous waste that is either disposed of in landfills or incinerated. Treatment of hazardous waste involves governmental costs for monitoring and control. These costs will drop significantly when treated poles are replaced by alternate material poles.

Possible management options under the POP protocol

The objective of the POPs protocol is to control, reduce or eliminate discharges, emissions and losses of persistent organic pollutants. In order to remediate concerns and risks related to the production and use of PCP, it would be possible to:

- List PCP in Annex I of the protocol in order to eliminate its production and use.
- List PCP in Annex II of the protocol in order to eliminate certain uses.
- List PCP in Annex III of the protocol in order to reduce total annual unintentional emissions.

Discussion of the options

PCP could be listed in Annex I. The only current application of PCP which is affected by this option, is the pressure treatment of wood in North America. Alternatives are available and have proven applicability, although the long term performance of some alternatives is doubted. Since consumption volumes in North America are still relatively high, a switch to alternatives needs investments and will require time. The major challenge for industry is selecting the right alternative that is the most cost efficient replacement. A step-wise phase-out for the most critical use is considered to be achievable. The term of ending the most critical use together with its related conditions can be identified in Annex I.

When PCP is listed in Annex I there is no need to list it in Annex II as well. Alternatives are available. None of the current applications is known to be completely dependant on PCP.

It is of no value to list PCP in Annex III, since PCP is proposed for listing in Annex I. Furthermore, listing a substance in Annex III means inventorising the emissions of PCP.

Waste management techniques for PCP-containing waste can be addressed in the guidance document on BAT. The measures to control emissions of dioxins, furans and HCB from waste incineration as described in the guidance document will be effective for PCP as well.

1 Introduction

PCP under the POP Protocol

At the twenty-fifth session of the Executive Body PCP was submitted for amendment to the Protocol. In support of the proposal of PCP to be considered as POP a dossier on PCP was prepared by Poland in May 2008. At the request of the Executive Body the Task Force conducted a technical review of this dossier and reported on progress to the Working Group on Strategies and Review (WGSR). Some Task Force members concluded that there was insufficient information to conclude that PCP is likely to have significant adverse health and/or environmental effects as a result of long-range transboundary atmospheric transport. However, at its forty-fifth meeting the WGSR noting these reservations, recommended the Task Force to pursue the track B work for PCP.

With respect to track B the Task Force was charged to draft a summary report of management options for PCP. This summary report will be submitted to the WGSR and the EB in September and December 2010, respectively. The Netherlands were asked to take on the preparation of the document.

Preparation of this document

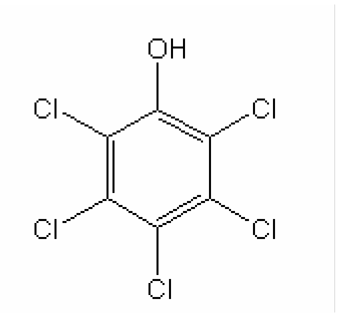
The Task Force at its seventh meeting in Plovdiv, 2009, agreed that a questionnaire be sent to all Parties to the Protocol and to other stakeholders from industry to gain a better view on management strategies and options for PCP in Europe and North America. This questionnaire, sent in January 2010 addressed production, import, use, articles, recycling, emissions, alternatives and technologies to reduce the emissions of PCP to the environment. The questionnaire has resulted in 17 valuable responses regarding PCP, of which 2 came from industry. The Pentachlorophenol Task Force representing the manufacturer of PCP in the U.S, and the Utility Solid Waste Activities Group (USWAG), representing the electric generating industry in the U.S. provided information.
The responses received from the survey, together with information available in literature and on the internet were used to compile this document. When evaluating PCP, the dossier, the addendum and this document should be assessed together.

Chapter 2 provides information on the characteristics of PCP. Chapter 3 gives an overview of the known current sources of emissions in the UNECE region. Chapter 4 presents information on management options, like legislation, alternatives and other control measures. The references used as sources of are listed in chapter 5.
A summary of the responses to the questionnaire is presented as an annex to this document.

2 Characteristics of Pentachlorophenol

Pentachlorophenol (PCP) is an aromatic hydrocarbon of the chlorophenol family.

Chemical structure:



Chemical Formula: C_6Cl_5OH.
Chemical Abstract Service (CAS) registry number: 87-86-5
Abbreviation: PCP

Table 1. Physical and chemical properties of PCP[1, 2, 3]

Melting point	191°C for pure PCP, 187-189 ºC for technical PCP
Boiling point	310 °C (decomposes)
Vapour pressure	2 mPa at 20 °C, 16 Pa at 100 ºC
Log K_{ow}	5.12 – 5.18
Solubility	Soluble in benzene, ethanol and ether Slightly soluble in water
Appearance (pure form)	White solid with needle like crystals
Molecular mass	266.34 g/mol
Density	1.987g/ml at 22 °C

Pure PCP exists as a colourless to white crystalline solid. Impure PCP, which is usually found at hazardous waste sites, is dark gray to brown and exists as dust, beads, or flakes It is soluble in most organic solvents, but poorly soluble in water at the slightly acidic pH generated by its dissociation. However at higher pH it forms highly water-soluble salts and at the close to neutral pH of most natural waters, PCP is more than 99% ionised.

The relatively high volatility and mobility of PCP and the water solubility of its ionized form have led to the widespread contamination of all environmental sectors, and a long-range dissemination of this compound. PCP will leach from treated wood, volatilise from treated surfaces and may get into waterways [20].

Commercial PCP contains very toxic impurities. Those of great concern are the polychlorodibenzodioxins (PCDD), polycholorodibenzofurans (PCDF) and hexachlorobenzene (HCB). Several sources of information have reported the presence of these impurities [5, 9, 10, 16]. The toxic characteristics of PCP as well as its contaminants may have consequences for the health of people who are exposed to articles treated with PCP frequently, like electrical utility linemen and pressure treatment operators [11].

Na-PCP and PCPL

The salt sodium pentachlorophenate (Na-PCP) is used for similar purposes as PCP and readily degrades to PCP. The environmental toxicity, fate and behaviour profile of PCP and

Na-PCP are quite similar. The same applies for the ester pentachlorophenyl laurate (PCPL) Where relevant, additional information on Na-PCP and PCPL is included in the document. Na-PCP is registered with CAS number 131-52-2, PCPL with CAS number 3772-94-9.

Penta
Commercial PCP is sold as ‘penta’ by its manufacturer. Penta includes various PCP-formulations with slightly different contents sold as wood preservative. Only when the information processed in this document concerns the sold product in general, this is referred to as penta [13, 14].

3 Current sources of emission

Production and use

Production worldwide

The world wide production of PCP in 1981 was estimated to be 90,000 tonnes per year [5]. No recent data on the amount of PCP produced globally are available. It is likely that the world wide production level has decreased, since the PCP-demand has declined over the last years. According to the dossier on PCP China belongs to the PCP producing countries outside the UN-ECE region with an annual production volume of 5000 tonnes.

Production in the UN-ECE region

In most European countries the production of PCP ceased in the mid-nineties. Before that time, it was produced in Poland, Germany, the Netherlands, Denmark, Switzerland, United Kingdom, Spain and France. In Spain production stopped in 2003. After production stopped PCP was imported to the European market from the U.S.
In Canada production stopped before 1990.

At the moment there is one company in North America –as can be verified – manufacturing the substance: KMG Bernuth [13]. Production facilities are located in the U.S. Tuscaloosa (Alabama), Wichita (Kansas) and Matamaras (Mexico).
KMG supplies PCP and creosote to the wood preservation industry in the U.S, Canada and Mexico. The wood preservation industry uses these products to extend the useful life of wood, primarily utility poles and railroad crossties, protecting them from insect damage and decay. The company's commercial PCP-preservation products are referred to as ‘penta’. They include penta blocks, flakes, solutions and the sodium salt Na-PCP [14]. In the facilities in Tuscaloosa (Alabama)and Matamoros (Mexico) solid penta is converted into liquid solutions. The penta segment constituted 14% of the company's net sales in 2009 [13].
KMG-Bernuth produced Na-PCP until 2006, when it stopped production of that product. KMG-Bernuth has never produced PCP laurate esters [16].

The production plant in Wichita was formerly owned by the Vulcan Materials Company. In 2002 Vulcan produced 1361 – 1815 tonnes PCP [16].
In 1996 the production volume of the production plants present in North America at the time was 8,270 tonnes. Production levels from 1995 to 2002 are presented in the table below [3].

Table 2: PCP-production and -consumption

Year	***Production volume in the U.S. (tonnes)***	***Consumption volume in the U.S. (tonnes)***
1995	8600 - 9500	7300
1996	8100 - 9100	7300
1997	8100 - 9100	7300
1998	8100 - 9100	7300
1999	7300 - 8100	6800
2000	7300 - 8100	-
2001	< 4500	-
2002	< 4500	5000 - 5500

More recent data come from the Pentachlorophenol Task Force: KMG Bernuth in the U.S. produced 7,257 tonnes in 2009, marketed to the US, Canada and Mexico for wood preservation [16]. This matches the production level in 2000.

Historic use
PCP was first introduced for use as wood preservative in the 1930's. Since it's introduction PCP has had a variety of other applications in industry, agriculture and domestic fields as well. Within the UN-ECE region it was widely used as biocide, pesticide, disinfectant, defoliant, anti-sapstain agent, anti-microbial agent and wood preservative. Wood preservation was by far the major application
PCP was also used for the production of pentachlorophenol laurate (PCPL), used on textiles and other fabrics. The dossier on PCP gives an overview of all different applications [5]. These include Na-PCP and PCPL as well.

Current use
Domestic use, such as indoor application of wood preservatives and paints based on PCP or PCP-treated indoor wood panels and boards, may lead to high concentrations in the indoor atmosphere. Most developed countries have found it necessary to ban the use of PCP for this purpose. Many countries have restricted the agricultural use and use in fabrics as well. In the UN-ECE region PCP nowadays is solely used as wood preservative in the industrial market. No data are found indicating otherwise.

Na-PCP and PCPL
In response to the questionnaire Canada reports that the use of Na-PCP for wood preservation stopped in 1981. Use of PCPL has never been registered in Canada. For the U.S. this is unclear.
The dossier on PCP reports that the use of Na-PCP and PCPL ceased in 2008 for all EU-member states. Finland reports that the use of Na-PCP in Finland stopped in 2000. In Spain Na-PCP was used in the past for wood treatment applications. Actions to restrict the PCP and its salts and esters on use were already taken.

Wood preservation
Current PCP-consumption for wood preservation concentrates in North America. In Europe PCP is presumably no longer used for wood preservation, as can be concluded from the responses to the questionnaire and the dossier on PCP. It is not possible to verify this for all European countries, especially the ones outside the EU.

Penta belongs to the three major wood preservatives used in the industrial market in North America. The other two are chromated copper arsenate (CCA) and creosote. In North America the only currently registered use of penta is for pressure and thermal treating of railway ties, utility poles, pilings and outdoor construction materials. In their response to the questionnaire Canada and the U.S. have confirmed this. Penta is no longer available to the general public and its use and purchase are restricted to certified applicators.
The majority of penta used in North America is for treatment of poles: treatment of utility poles and cross-arms account for more than 90% of PCP-consumption [3]. The PCP Task Force confirms these data in response to the questionnaire [16]: Utility Poles and Cross-arms (90% of market), laminated beams for bridge construction (5% of market).

In Canada the wood treatment industry exists of about 66 plants in 1999 [15]. It is unclear if all these plants use penta as wood preservative. In the U.S. approximately 40 wood preserving plants use penta, as present in the end of the nineties. Of these plants ten also use CCA and six also use creosote (two of which use all three preservatives) [3].
More recent data are not available.

Consumption volumes
The total amount used in Canada is estimated at 147 tonnes [16] which is imported from the U.S. The U.S. consumption is expected to be much higher. In 2002 approximately 5,000 tonnes of PCP were used [16]. For that same year about 130 million to 135 million treated wood poles were estimated to be in service in the U.S. [17]. An estimated 2-3% of the treated poles are replaced annually. This means that, without reuse or recycling, about 3 to 4 million poles are renewed in the U.S every year. This matches the data found in other

documents: in 2004 3.9 million poles were preserved, 40% of which were treated with penta [12]. The remaining poles were treated with CCA (44%) and creosote [3].

In the lumber and timber market, waterborne salts (primarily CCA) have traditionally had the largest share of the market. In 2004, waterborne preservatives were used to treat 11.3 million m^3 of lumber and timber (>99 % of the market) while penta accounted for only approximately 0.08 million m^3 (0.1 %) in this market [3].

Emissions from production and use

Releases from production facilities

The dossier on PCP presents data on the releases of PCP and its impurities from production facilities. In the case of an annual production of approximately 2000 tonnes of PCP, about 18 kg PCP, 9 kg of other chlorophenols, 1 kg of chlorobenzenes and 0.2 kg of dioxins are released to air. With respect to the production of 2000 tonnes of Na-PCP/year, air emissions are much higher: 65 kg PCP, 5 kg other chlorophenols, 105 kg HCB, 700 kg other chlorobenzenes, 0.2 kg dioxins. [5].

The waste remaining from production contains several hazardous substances as well. The waste is generally disposed of by either storage in underground disposal sites or by incineration at high temperatures.

Releases from wood treatment plants

Wood treatment facilities emit PCP from different sources [7].

Liquid discharges may include:

- condensates removed from the wood during conditioning and during the initial application of vacuum;
- water released by the wood during the treating cycle and subsequently separated from the unabsorbed treatment oil prior to recycling of the oil;
- condenser cooling waters, which are not normally contaminated and are discharged without treatment;
- surface runoff from treated wood storage areas, which can contain preservative.

Solid waste from PCP oil-borne pressure treatment facilities may include:

- wood debris, treated or untreated such as cut offs and broken sections of product;
- contaminated filters;
- sludges from tanks, sumps and pressure cylinders;
- sludges from wastewater treatment processes;
- containers or wrappings and pallets from bulk PCP;
- contaminated soils.

Air emissions from PCP oil-borne pressure treatment facilities are generally localized and may include:

- vapours from block storage;
- emissions during wood conditioning and the final vacuum step;
  - vapours from tank vents;
  - vapours from venting cylinders;
  - vapours from opening of cylinder doors;
  - vapours from freshly treated charges.

Table 3 is extracted from the TRI-database. Data concern on and off site releases of PCP to air, to water, disposal in landfills and other releases (like underground injection) in kg/year. Registered PCP-data come from the wood products industry (including wood preservation facilities), hazardous waste handling (including waste treatment, disposal, incineration) and other industrial facilities. Although data vary over the years, the emission data show that the wood products industry as well as hazardous waste handling contribute to a large part to the amounts released.

Table 3: On- and off site disposal and releases of PCP in kg per year from industry in the U.S. Industry concerns Wood products (NAICS code 321), Hazardous waste/solvent recovery (NAICS code 562), Other: Chemicals (NAICS code 325), Chemical wholesalers (NAICS code 4246) [12]

Year	Industry	Air	Water	Landfills	Other	Total
2002	Wood products	46	293	5030	2	5372
	Hazardous waste/solvent recovery	3	159	121	0	238
	Other	11	-	0	0	11
	Total	**60**	**407**	**5152**	**2**	**5621**
2003	Wood products	142	270	626	2	1040
	Hazardous waste/solvent recovery	1	159	116	0	231
	Other	77	0	0	1	78
	Total	**220**	**384**	**742**	**3**	**1349**
2004	Wood products	32	315	917	10	1274
	Hazardous waste/solvent recovery	0	15	7681	0	7696
	Total	**32**	**330**	**8598**	**10**	**8970**
2005	Wood products	31	225	599	3	858
	Hazardous waste/solvent recovery	9	15	230	0	254
	Other	25	0	0	6560	6585
	Total	**65**	**241**	**829**	**6563**	**7698**
2006	Wood products	26	186	381	0	594
	Hazardous waste/solvent recovery	20	13	119	363	515
	Other	0	0	85	0	85
	Total	**46**	**199**	**584**	**363**	**1193**
2007	Wood products	33	208	420	366	1026
	Hazardous waste/solvent recovery	8	13	227	0	249
	Total	**41**	**221**	**647**	**366**	**1275**
2008	Wood products	165	489	694	0	1348
	Hazardous waste/solvent recovery	6	24	1107	43	1180
	Other	0	0	64	0	64
	Total	**171**	**513**	**1865**	**43**	**2591**

Releases from the use in agricultural fields

When PCP is used for agricultural purposes, the amounts used will directly or eventually enter the environment. As far as can be verified at the time of drafting this document PCP is no longer used for agricultural purposes in the UN-ECE region. Subsequently no recent emission data related to former usage in agriculture were found.

Unintentional emissions

Microcontaminants in PCP

Polychlorinated dibenzo-p-dioxins (PCDD), polychlorinated dibenzofurans (PCDF) and chlorobenzenes are formed as impurities during the manufacturing process of PCP. The range and concentrations of the impurities vary depending upon the manufacturing method and upon process conditions. PCP can be manufactured by direct chlorination of phenols or by hydrolysis of hexachorobenzene. Formation of dioxins and furans may be promoted by conditions which favor the formation of chlorine or other halogen radicals and alkaline condition [9,10]. The table below shows detected levels of microcontaminants found in PCP-products in Canada [16].

Table 4: PCP microcontaminants of concern in Canadian products, provided by Canada [16]

Microcontaminant	CAS #	Level Detected			Remark
		From	To	Unit	
Hexachlorobenzene (HCB)	118-74-1	8.5	17.1	ppm	n = 7
Pentachlorobenzene (QCB)	608-93-5	Expected to be present - recent addition to CEPA schedule 1, no data provided, will be requested with re-eval.			
Tetrachlorobenzenes (TCBs)		Expected to be present – recent addition to CEPA schedule 1, no data provided, will be requested with re-eval.			
1,2,3,4-Tetraclorobenzene	634-66-2				
1,2,3,5-Tetraclorobenzene	634-90-2				
1,3,4,5-Tetraclorobenzene	95-94-3				
2,3,7,8-TCDD	1746-01-6	0.028	0.175	ng/g	“
1,2,3,7,8-PeCDD	40321-76-4	0.247	1.080	ng/g	“
1,2,3,4,7,8-HxCDD	39227-28-6	1.1	86.8	ng/g	“
1,2,3,6,7,8-HxCDD	57653-85-7	232.0	344.0	ng/g	“
1,2,3,7,8,9-HxCDD	19408-74-3	14.8	203.0	ng/g	“
1,2,3,4,6,7,8-HpCDD	35822-46-9	4570.0	13500.0	ng/g	“
OCDD	3268-87-9	34000.0	130000.0	ng/g	“
2,3,7,8-TCDF	51207-31-9	0.022	0.068	ng/g	“
1,2,3,7,8-PeCDF	57117-41-6	0.099	0.309	ng/g	“
2,3,4,7,8-PeCDF	57117-31-4	0.431	2.740	ng/g	“
1,2,3,4,7,8-HxCDF	70648-26-9	176.0	577.0	ng/g	“
1,2,3,6,7,8-HxCDF	57117-44-9	12.0	38.2	ng/g	“
2,3,4,6,7,8-HxCDF	60851-34-5	34.9	245.0	ng/g	“
1,2,3,7,8,9-HxCDF	72918-21-9	31.1	178.0	ng/g	“
1,2,3,4,6,7,8-HpCDF	67562-39-4	3140.0	17700.0	ng/g	“
1,2,3,4,7,8,9-HpCDF	55673-89-7	681.0	3150.0	ng/g	“
OCDF	39001-02-0	54400	283000	ng/g	

When PCP is produced, used, processed or when PCP-articles are used or disposed of as waste, releases to the environment of the microcontaminants are likely to occur. Emission data for dioxins, furans and HCB coming from wood treatments plants and from treated wood in and out of service (land filled) are given in the dossier on PCP [5].

Releases from treated wood in service

Although the volume of wood treated with PCP has declined over the last decade, a significant part of the wood treated years ago still is in use. For example, treated railway ties have an average service life of approximately 30 years (5 years without treatment).

Wood preservatives have been shown to migrate out of poles, contaminating soil and water. The outer layers of treated wood contain up to several hundred mg/kg of PCP. Due to volatilization, air levels of PCP in proximity to large amounts of treated wood or in confined spaces, may be significantly higher than background levels. PCP has historically been estimated to volatilize from the surface of treated wood roughly at 2% of the total amount of the preservative applied [5].
Evidence of PCP-leaching directly into the environment is found in several documents [2, 5, 18, 21]. Levels found differ. In 1992, a study by Environment Canada found PCP at high levels in utility and railway ditches, including concentrations of PCP averaging 1060 mg/kg at the base of poles [21]. In a follow-up study, Environment Canada found that PCP's contaminants were leaching out of PCP-treated utility poles and railroad ties. A third study conducted for Environment Canada found three poles treated with PCP that were adjacent to drinking water wells caused water contamination [18].

Releases from fabrics treated with PCP
It is not possible to provide data on volumes and emissions from treated fabrics and textiles in use. Since PCP/PCPL is still used in parts of the world outside the UN-ECE region for this purpose, it may to a lesser extent affect the environment through inflow of goods. These may concern imported textiles, domestic furniture and tropical wood products.

Contaminated sites
Highly contaminated areas from former production facilities or treatment plants may still cause an impact on the environment via transport to air and water. In Sweden relatively high levels of PCP have been detected at contaminated sites, where preservation of wood has taken place.

Releases from waste handling
After service life articles treated with PCP are either incinerated, disposed of in landfills, reused or recycled. It is unclear to what extent these articles are incinerated, land filled or reused and recycled. In Germany for example all preserved wood is incinerated. For other countries this is unclear. Releases from land filled articles are mainly in leachate. According to the Agency for Toxic Substances and Disease Registry, 445 hazardous waste sites in the U.S. have been contaminated with PCP.

When PCP-treated articles are burned dioxins and furans may be formed.The formation depends on operating conditions. When waste is burned at uncontrolled conditions – like in open fire or in barrel burning – this may result in higher dioxin an furan emissions than from waste incineration under controlled conditions (large scale installations).

In Canada utility poles/pilings are buried in landfill sites approved for the disposal of toxic waste; some users separate outer treated surface from inner core to reduce waste quantity. Recycling options for treated utility poles were discussed with industry as part of the Waste Management Issues Working Group within the Strategic Options for the Management of CEPA-Toxic Substances Project lead by Environment Canada [16].

In the U.S. EPA reports that discarded PCP treated lumber is usually land disposed in either construction and demolition landfills, municipal solid waste landfills, or industrial non-hazardous waste landfills [11].

As table 3 shows, hazardous waste handling contributes to a large extent to PCP-releases. A large number of treated wood poles are still in use. When they become waste, this generates an ongoing source of emissions of PCP, dioxins, furans and HCB. As estimated in one of the former paragraphs, approximately 1.5 million poles treated with penta become waste assuming no reuse or recycling.

4 Management options

Overview of existing legislation in the UN-ECE region

Canada

Since all chlorophenols used in Canada have pesticidal properties, products marketed in Canada, which contain chlorophenols, are registered under the Pest Control Products Act, administered by Agriculture Canada. The heart of the act lies in the registration requirements. The act prohibits any person from importing or selling any control product unless it has been registered, packaged, and labelled according to prescribed conditions. Pesticides may be registered only if the Ministry of Agriculture is of the opinion that the control product has merit or value for the purpose claimed, when used in accordance with label directions. PCP imported for use into Canada is reviewed as part of the registration process under the Pest Control Products Act. Microcontaminant levels must remain consistent with product specifications filed and reviewed as part of the registration process. PCP use must be consistent with the product label under the Pest Control Products Act.

Wood treatment facilities must conform with the Technical Recommendation Documents for the Design and Operation of Wood Preservation Facilities (TRDs) which were negotiated with industry as part of the Strategic Options for the Management of CEPA-Toxic Substances lead by Environment Canada [7].

U.S.

In the United States, under the Emergency Planning and Community Right-to-Know Act of 1986, release of more than one pound of PCP into air, water, or land must be reported and entered into the national Toxic Release Inventory (TRI). In 1974, the Safe Drinking Water Act was passed, that requires that the MCLG(maximum contaminant level goals) level for PCP was set at zero. In 1987, the U.S. Environmental Protection Agency (EPA) limited the use of penta for industrial wood preserving uses in the United States and banned its use for any other application; it has no registered residential uses [3].

Health Canada's Pest Management Regulatory Agency (PMRA) and the US Environmental Protection Agency (EPA) are currently conducting a cooperative re-evaluation of PCP under the North American FreeTrade Agreements (NAFTA) Technical Working Group (TWG) on Pesticides. The preliminary findings of this evaluation can be found on the US EPA website.

There are also hazardous waste regulations under the Resource Conservation and Recovery Act (RCRA) that apply specifically to wastes generated at facilities where wood preservatives are used to treat wood [11].

European Union

Within the EU the marketing and use of substances and preparations to which PCP or its salts and esters have been added intentionally in a concentration equal to or greater than 0,1% by mass is banned since 2000 with the Council Directive 1999/51/EC. Some member states were permitted to choose not to apply the total ban until December 31, 2008. This derogation has ended by now. It is very likely that all EU-members have banned the use by autonomous measures. For outside the EU this is unkown.

PCP is listed as chemical in Annex III of the Rotterdam Convention. For each chemical listed a decision guidance document is prepared and sent to all Parties of the convention with a request that they take a decision on import of the chemical. All Parties are required to ensure that their exports do not take place contrary to an importing Party's import decision.

National legislation in European countries

Some European countries – Norway, Denmark, Germany, Netherlands and Austria - have introduced national legislation on PCP in products that is stricter than the harmonised EU legislation. EU legislation is only applicable to the use of PCP within the EU Member States. National legislation restricts the presence of PCP in products placed on the national market. In the Netherlands for example the trade and import of articles containing more than 5 mg PCP/kg is strictly prohibited since 1997.

In the Ukraine PCP is included into the List of pesticides banned for usage in agriculture, registration and re-registration (1997). Furthermore, the maximum residue limits for PCP in various media, as well as references on the corresponding analytical techinques are included into state sanitary rules and norms. Belgium reports that PCP was never authorized as pesticide. In 1987 the authorization as biocide is withdrawn. Cyprus confirms that PCP is restricted under national legislation. The Spanish National Implementation Plan of the Convention Stockholm and Regulation 850/2004 on Persistent Organic Pollutants.

In Switzerland the production, import and use of PCP have been prohibited by law since 1986. This general prohibition has been taken over in the Swiss Ordinance on Chemical Risk Reduction (ORRChem) since 2005. Additionally the ORRChem put a ban on wood-based materials containing more than 5 ppm of PCP since 2006 [16].

Substitution and alternatives and emission control techniques

Agricultural use

PCP has been replaced by other chemical agents for virtually all of its former agricultural uses.

Use in textiles and other fabrics

No current use for the impregnation of textiles and fabrics is reported. This indicates that PCP and PCPL-use is replaced by other chemicals or by alternative techniques.

Wood preservation facilities

In Canada environmental releases from wood preservation facilities have been reduced to the extent possible by the utilization of the Technical Recommendation Documents (TRD). Wood treatment facilities must conform with the guidelines of the TRDs for the design and operation [7].

Handling treated wood in service and after service

Exposure to PCP by workers or consumers may be reduced wearing protective clothing, gloves and boots. EPA and USWAG developed a set of comprehensive guidelines for the use and management of treated wood in a safe and environmentally-protective manner. Among other things the aim is to promote reuse by reusing treated wood products where appropriate, and to ensure that persons who obtain used, treated wood products for continued use are informed with regard to the proper handling, use, and disposal of treated wood products [17]. Since these are guidelines, there is no guarantee that end consumers always will handle in line with the guidelines.

Waste incineration

PCP-treated wood in the waste phase must be treated as hazardous waste. When PCP-treated wood is disposed of in landfills, PCP and microcontaminants still leach into the environment. The disposal of this waste and other PCP-containing waste should preferably involve controlled high-temperature combustion [5]. PCP treated wood combusted at 910 ºC – 1025 ºC resulted in no detectable chemicals in the off gas. However, the incineration temperature needs to be high enough and the resident time long enough to fully degrade the PCP, as it combusts incompletely at temperatures under 800 ºC. High temperatures are also needed to reduce the formation of dioxins and furans. Effluent gas scrubbing reduces the release of hydrogen gas [20].

Chemical alternatives for treatment of textiles
In response to the questionnaire Spain has given several alternative chemicals for the preservation and impregnation of textiles. These are aqueous mixtures of metals as copper, chromium and arsenic, zinc-2-pyridinthiol-N-oxide, 2,2´-dihydroxy-5,5´-dichloro-diphenylmethane ester [16].

Chemical alternatives for wood preservation
For wood preservation a number of chemical alternatives for penta have been developed. Alternatives may not all be completely interchangeable. Efficacy, technical feasibility and cost play an important role in evaluating chemical alternatives. To be effective, a wood preservative must possess the following properties:

- toxicity towards wood-destroying organisms
- ability to penetrate deeply into wood
- permanence in the treated wood
- it must not have damaging effects on the wood itself
- it must be non-corrosive to metals
- it must not damage the health of those involved in its manufacture, transport or use or any buyers/consumers of impregnated wood [23].

The chemical alternatives presented in this document include chromated copper arsenate (CCA), creosote, copper and zinc naphthenates, ammoniacal/alkaline copper quaternary (ACQ), copper azole (CBA), sodium borates (SBX), and copper HDO (CX-A).
EPA has conducted a ***'****Qualitative Economic Impact Assessment of Alternatives to Pentachlorophenol as a Wood Preservative'* in which the benefits, adverse effects and qualitative economic aspects are elaborated of several alternatives for wood preservation in North America [3]. The aspects per alternative as reported in the EPA-document are summarized below. The Spain response to the questionnaire adds other alternatives, like diclofuanide, propiconazole, 3-yodo-2-propinyl-buthylcarbamate.

Chromated Copper Arsenate (CCA)
CCA is approved for use in piles and posts and is also approved for salt water use.
Advantages: Wood treated with CCA is dry, odourless and residue free. Since CCA is chemically bonded with the wood there is lower risk of leaching. This makes CCA-wood particularly suitable for areas with high soil moisture, where the water table is high, or where water is perched at a shallow depth or where occasional freshwater flooding is likely.
Disadvantages: CCA is very toxic. The treated wood has a tendency to warp or crack. CCA-treated poles are more difficult to climb. Although the AWPA has standardized the use of CCA for Douglas-fir sawn cross-arms and poles, it is difficult to adequately treat Douglas-fir with CCA. This is the case because Douglas-fir consists primarily of heartwood which is laden with extractives. The extractives block the wood pores, and water based preservatives, such as CCA, have difficulty penetrating to an adequate depth. Douglas-fir is commonly used in western United States for utility poles. The dryness of CCA-wood becomes a disadvantage in regions with a very hot and dry climate. CCA-treated wood accelerates corrosion of untreated metal fasteners, so that hot-dipped galvanized steel hardware is recommended (which is already standard in industry).

Creosote
Creosote is the oldest known wood preservative. It is available in many different forms and is approved for full exposure to above ground, soil and freshwater use in lumber, timbers and plywood. It is approved for use in piles and posts and is also approved for saltwater. Currently creosote is the only preservative used in treating crossties and switch and bridge ties in the U.S.
Advantages: Creosote treated poles are standardized for use in saltwater. It also has an advantage in areas where the climate is hot and dry and where there is ice and/or wind. Creosote-treated poles have material properties and working quality that are well known. Corrosion of hardware is not an issue, in fact it may be reduced in the presence of creosote. Because creosote is oily, the treated wood is somewhat water repellent. This improves the

wood's dimensional stability and reduces checking and splitting. Creosote treated wood is also more resistant to mechanical wear, which is of vital importance for such applications as railway ties and bridge decking.
Disadvantages: Disadvantages are toxicity, unpleasant odour, difficulty in painting, harmful vapours and its potential to be a source of contamination [3].

Copper Naphtenate
Copper naphtenate is an oil borne preservative that is approved for full exposure to above ground, ground contact and freshwater applications. It is approved for pressure treating of lumber, timber, utility poles, foundation piling and posts. However, it is not approved for saltwater use.
Advantages: Several environmental disadvantages over conventional wood preservatives. EPA does not regulate copper naphtenate waste as hazardous waste nor emissions from treatment plants as air pollutants. Corrosion of metal is not an issue.
Disadvantages: Not approved for saltwater use and they leave an oily residue in the wood. Leaching of copper in soil and aquatic systems can be an issue when disposing copper napthenate treated wood. USWAG has reported that copper naphtenate treated utilities have shown higher failure rates than typically treated poles (penta, creosote, CCA) [3].

Ammoniacal/ Alkaline Copper Quaternary (ACQ)
ACQ is a waterborne preservative approved for full exposure above ground, ground contact and freshwater applications. It is not recommended for use in saltwater.
Advantages: It has been successfully used in Europe, Japan, New Zealand, Asia and Australia, and it has been commercially available in some parts of the U.S. for several years. ACQ formulations are standardizes by AWPA as waterborne preservatives for Southern Pine as lumber, timber, and bridge and mine ties.
Disadvantages: ACQ is not recommended for saltwater use. Relative to CCA it is more corrosive to metal fasteners [3].

Ammoniacal Copper Zinc Arsenate (ACZA)
ACZA is a waterborne fixed wood preservative that is approved for exposure to above ground, ground contact, saltwater and fresh water applications.
Advantages: ACZA is leach resistant and therefore safe for aquatic environments.
Disadvantages: ACZA treated wood has similar characteristics as CCA-treated wood, but it gives off an ammonia odour. It tends to corrode metal fasteners so that stainless steel or hot-dipped galvanized steel fasteners should be used [3].

Other
Copper azole (CBA) is a water-based preservative. It is not standardized for use in semi-tropical and tropical regions and not for saltwater use.
Sodium Borates (SBX) is a preservative that is only approved for above ground applications that are continuously protected from water [3].

In table 5 on the next page an overview of the alternative wood preserving chemicals is given with respect to its applications. There is no application that is completely dependant on PCP. For every application one or more alternatives are given.

The costs for wood poles treated with alternative chemicals compared to that of wood poles treated with PCP are about the same. When CCA is used additional costs are involved with softening agents, when ACQ and copper azole are used additional costs are involved with stainless steel hardware. Considering the additional costs as well the rate of alternative to PCP treated wood pole cost is less than 1.4 [3].

Table 5: Applicability of wood preservatives according to AWPA standards [3]

Product/application	Oil borne preservatives					Waterborne preservatives					
	Creosote	Creosote-Petroleum	Creosote Solution	PCP	Copper Napthenate [4]	CCA [5]	ACQ- type C and type D	ACQ-type B	Copper Azole type B	Copper Azole type A	ACZA
Lumber, timbers and Plywood											
C2-lumber, timber, bridge ties and mine ties	+	+[1]	+	+[1]	+[1]	+	+[1]	NA	+[1]	+[1]	+
C9-Plywood	+	+	+	+	NA	+	+	NA	+	+	+
C22-Permanent Wood Foundations	NR	NR	NR	NR	NA	+	+	+	+	+	+
C28-Glued laminated members	+	NA	NA	+	+	+	+	NA	NA	NA	+
Piles											
C3-piles	+	+	+	+	+[2]	+	+	NR	NR	NR	+
C18-Marine construction	+	NR	+	NR	NA	+	NR	NR	NR	NR	+
C21-marine lumber and timbers	+	NA	NA	+	+	+	+	NA	+	+	+
C24-sawn timber used to support residential & commercial structures	+	NA	NA	+	NA	+	+	NA	NA	NA	+
Poles											
C4-poles	+	NR	+	+	NA	+	NR	+	NR	NR	+
C23-round poles and posts used in building construction	+	NR	NR	+	NA	+	NR	NR	NR	NR	+
Posts											
C5-Fence Posts	+	+	+	+	+	+	+	+	+	+	+
C14-wood for highway	+	+	+	+	+	+	+	+[6]	+[3]	+[3]	+
C15-wood for commercial residential construction	+	+	+	+	+	+	+	NA	+	+	+
C16-wood used on farms	+	+	+	+	NA	+	+	NA	+	+	+
Crossties and switch ties											
C6-crossties and switch ties	+	+	+	+	NR	NR	NR	NR	NR	NR	NR

NA: Not available, NR: not recommended

1. *Not for saltwater use*
2. *Land and freshwater use; not for foundations*
3. *Posts sawn four sides only*
4. *Copper Naphtenate is also approved by AWPA as a waterborne preservative for some uses.*
5. *CCA is available for industrial applications only.*
6. *Round, half-round, and quarter-round only.*

Non-chemical alternatives for wood preservation

Non-chemical alternatives concern replacement of material by steel, concrete, fibre reinforced composite, naturally resistant wood and some other alternatives.

Switch to concrete poles

Concrete poles are engineered structures and therefore have other physical characteristics than wood poles.

Advantages: Concrete poles do not twist or warp and stand up well to short duration fires. Leaching of chemicals is not an issue. Because of their density concrete poles are very

durable. The life expectancy of concrete poles is much higher than that of treated wood poles.
Disadvantages: The main disadvantages of concrete poles are higher installation and freight costs due to weight. Design and installation to prevent electrocution of raptors is important which leads to additional costs. Concrete is subject to degradation in saltwater regions. Also freeze/thaw cycles may cause degradation of the material. The major disadvantage are the higher installation and freight costs due to weight [3].

Switch to steel poles
Advantages: Steel poles have many advantages over chemically treated wood poles. Steel offers more strength and durability against severe weather conditions. Steel poles weigh about 30 – 50 % less than comparable wood poles, which means that they are easier to handle and account for less freight costs. They can be fabricated to any height and strength. Steel can not be degraded by fungi and insects.
Disadvantages: Corrosion can be a problem with steel poles, primarily below the ground line. This can be prevented by coating or galvanising the steel. Steel poles have less insulation characteristics, so additional insulation is needed. They are more costly than wood poles. Gaffs which are used to climb wood poles are not usable with steel poles. Steel poles therefore need to be designed with permanent or removable steps [3].

Switch to fibreglass reinforced composite (FRC) poles
Advantages: FRC is lightweight and strong. FRC-poles can be hand carried to difficult spots. The manufacturers indicate that 40 years is a minimum life span with little or no maintenance. They are designed to meet the minimum standards for wood.
Disadvantages: FRC poles are more easily damaged , so that the surface of FRC must be carefully protected during transportation and installation. As steel poles, they require steps for lineman to climb the poles. Installation costs are significantly higher than that of wood poles [3].

Switch to decay resistant wood
These types of wood like tropical hardwood or american chestnut wood can potentially be used without chemical treatment.
Advantages: Hard wood poles have a higher mechanical strength than treated soft wood poles. They are climbable using the same techniques as for preserved wood poles.
Disadvantages: The main disadvantage is the high cost [3].

EPA gives data on costs of alternate materials. Based on Californian data the installed cost for steel, concrete and fibreglass poles are reported to be significantly higher than that of treated wood poles. An overview is given in table 6. However, the table does not include the maintenance costs which for all alternate materials are about half of that of treated poles ($9/pole). Costs for future inspection, maintenance and pole replacement add 5-11% to the value of wood installation costs and 0-1% to the value of installation of alternate poles. Furthermore, data does not take the longer life expectancy of alternate materials into consideration. For example, concrete poles may last over 50 years. Besides that, more wooden poles are required per km than concrete or steel poles [3].

Table 6: Comparison of installed total cost of alternate pole materials, based on Californian data.[3]

Description	Treated wood ($/pole)	Fibreglass ($/pole)	Steel ($/pole)	Spuncast concrete ($/pole)
New and replacement poles	450	1,000	500	500
Freight	50	50	120	200
Installation	300	300	300	600
Pole steps	0	150	150	150
Steps installation	0	150	150	150
Raptor protection	0	0	150	150
Installed total cost	800	1,650	1,370	1,750
Ratio of alternate to treated wood installed cost		2.06	1.71	2.19

Possible management actions

Production and consumption levels of PCP have decreased over the years. Legislation and the availability of alternatives account for this decrease. However, additional actions are required to phase out production and consumption of PCP. It is suggested to include Na-PCP and PCPL in the management actions as well, since the substances are closely related.

Production

As far as can be concluded from the information gathered, in the UN-ECE region only one company manufactures PCP (penta). This sole producer is located in the U.S. and supplies penta to the wood preservation industry in North America and Mexico.

Use

The majority of penta is used to extend the useful life of wood, primarily utility poles, pilings and crossties. In the UN-ECE-region only Canada and the U.S. have reported this application. At the moment of drafting this document there are no data present indicating other current applications of PCP, Na-PCP and PCPL in the UN-ECE-region. A restriction on the use for applications other than wood preservation is therefore expected to have no impact.

For decades PCP has been the preservative that power generation and telephone companies in North America use to protect their utility poles. Given this fact, the socio-economic impacts resulting from a ban on PCP-consumption will affect the North American industry most. For the use as wood preservative alternative chemicals as well as alternate materials are generally available and applicable. Which alternative performs comparably to PCP, varies upon the type of product and type of application. None of the applications of preserved wood known is completely dependant on PCP.
Although some of the alternative chemicals are more or less as toxic as purified PCP, like creosote, they do not all contain the persistent toxic contaminants that characterize formulated PCP products. Replacement of wood by material like concrete, steel and fibre reinforced composite that don’t leach, has even more environmental benefits.
According to USWAG an important aspect for selecting an alternative is the dependability of the product. Unlike some alternatives, wood poles have a proven track record. Some alternatives either don’t exist for the requisite period of time or have not been used for pole applications long enough to consider it proven. This may counteract with the fact that alternatives are in use for several years in European countries where the marketing and use of PCP-containing articles is prohibited. According to the European industry trade association representing the pressure treated wood industry (WEI) about 6.5 million m^3 of pressure treated wood per year is supplied by the wood preservation industry. About 11% is preserved with creosote, 71% with waterborne preservatives and 18% with light organic solvent preservatives [22]. Furthermore, steel and concrete are widely applied in Europe.

In the lumber and timber market only a small percentage of the wood is treated with PCP. When a ban on PCP is introduced, it is expected that PCP will be substituted by chemicals like CCA, ACZA, ACQ or that preserved wood is replaced by alternate materials.
The pole market may not move that easily. The existing electrical transmission and distribution system in the U.S. and Canada is mainly supported by wood poles, of which about half is treated with PCP. The other half is treated with either creosote or CCA. Besides CCA and creosote, copper naphtenate has demonstrated efficacy

Wood poles in and out of service

Estimations indicate that several million treated wood poles are purchased annually by electric utilities alone. In service as well as after service life treated wood poles leach PCP, dioxins, furans and HCB to the environment. When PCP is not phased out, these hidden reservoirs remain contaminating the environment. The relatively large volumes of PCP-poles in use remain a matter of concern for the environment. Although guidelines for handling, use and disposal are developed, end-users have no obligation to comply with these guidelines. Additional actions are required to phase out production and consumption of PCP.

Wood poles treated with PCP or Na-PCP are hazardous waste. In the waste phase they should be treated as such. Once land filled, treated poles may still leach PCP and microcontaminants into the environment. Therefore, incineration under controlled conditions is preferred over disposal to landfills.
The measures to control emissions of dioxins, furans and HCB from waste incineration are already covered in the guidance document on BAT (Annex V) of the POP-protocol. These techniques will be effective for PCP as well. Other management options concerning handling PCP-containing waste can be addressed in the guidance document on BAT as well.

Cost implications

Phasing out PCP gradually will affect the wood treatment industry and electric utility industry the most. Implementation of alternatives, either chemical or non-chemical, will consequently have economic effects and will require additional investments.

Costs of eliminating production
The sole producer KMG Bernuth (Vulcan Materials) is likely to be affected significantly by any restriction of PCP in the poles market. The company's sales of penta in 2009 were $26.2 million [13]. However, the producers of potential alternatives to PCP would likely benefit from any restriction of PCP and would experience an increase in sales as a result [3].

Costs of eliminating consumption
As estimated a couple of years ago about 50 to 100 PCP-using wood preservation facilities in North America are present. A possible unavailability of PCP would have a significant effect on these companies as they would have to shift capacity from PCP-treatment to other treatments. The treatment plants will have to upgrade equipment to accept new formulations. Additional investments will be required in most facilities to increase capacity or to expand their plants to treat using other alternatives. Wood treatment plants with capability to treat alternative chemicals would be able to adjust their capacity most easily if the use shifts from PCP to these chemicals. A move from PCP to waterborne preservatives would require expenditure on new equipment because it is a shift from an oil-based preservative to a waterborne preservative. In particular, wood treatment plants that shift to alternatives that are more corrosive, such as ACQ and Copper Azole, would have to change their fittings [3]. No quantitative data on cost implications are found.

Cost implications for consumers
Consumers presumably will not experience a significant impact from a ban on PCP in the pole market since several alternative chemicals to penta at reasonable cost are available. However, given the fact that penta has a large share in the market, there could be significant production shortages as wood treatment plants and producers transition from penta to one of the alternatives. This could lead to fluctuation in prices that could adversely affect consumers.
When a ban of PCP results in a transition to alternate material like steel or concrete, price increases are expected. The initial costs per pole are about two times higher than that of treated wood poles. The higher initial costs may be partly compensated by the fact that less poles are needed per km compared to wood poles and that the life expectancy compared to that of treated wood poles is higher.

In the lumber and timber market consumers will similarly not be greatly affected because CCA and other alternatives such as ACQ and creosote perform comparably in most uses. PCP is the preferred alternative in the treatment of cross arms; however, ACZA and ACQ may be suitable alternatives for this use as they can be used to treat Douglas fir wood, which is used in cross-arms. Other than chemical alternatives, a small percentage of the market may also go to alternatives to treated wood such as plastic and composite lumber or concrete. These alternatives are still substantially more expensive than treated wood, but some consumers have opted for these because of their non-toxicity and durability [3].

Cost implications for state budgets

The costs of a ban on PCP for the EU members states are zero, since this is already the case in the EU. Replacement has already taken place.

The costs for Canada and the U.S. are more difficult to estimate. Costs depend on the actions taken. There may be costs involved with adopted control measures, monitoring and communication. These costs can be compensated using charges or taxes to stimulate the phase out process. Furthermore, replacing wood poles by alternate materials will considerably reduce the annual volumes of hazardous waste that is either disposed of in landfills or incinerated. Treatment of hazardous waste involves governmental costs for monitoring and control. These costs will drop significantly when treated poles are replaced by alternate material poles.

Possible management options under the UNECE LRTAP POPs Protocol

The objective of the POPs protocol is to control, reduce or eliminate discharges, emissions and losses of persistent organic pollutants. In order to remediate concerns and risks related to the production and use of PCP, it would be possible to:

- List PCP in Annex I of the protocol in order to eliminate its production and use
- List PCP in Annex II of the protocol in order to eliminate certain uses
- List PCP in Annex III of the protocol in order to reduce total annual unintentional emissions.

Discussion of the options

PCP could be listed in Annex I. The only current application of PCP which is affected by this option, is the pressure treatment of wood in North America. Alternatives are available and have proven applicability, although the long term performance of some alternatives is doubted. Since consumption volumes in North America are relatively high, a switch to alternatives needs investments and will require time. The major challenge for industry is selecting the right alternative that is the most cost efficient replacement. A step-wise phase-out for the most critical use is considered to be achievable. The term of ending the most critical use together with it’s related conditions can be identified in Annex I.

When PCP is listed in Annex I there is no need to list it in Annex II as well. Alternatives are available. None of the current applications is known to be completely dependant on PCP.

It is of no value to list PCP in Annex III, since PCP is proposed for listing in Annex I. Furthermore, listing a substance in Annex III means inventorising the emissions of PCP.

Treating hazardous waste involves careful handling. Waste management techniques for PCP-containing waste can be addressed in the guidance document on BAT. The measures to control emissions of dioxins, furans and HCB from waste incineration as described in the guidance document will be effective for PCP as well.

5 References

1. Agency for Toxic Substances and Disease Registry, Internet HazDat - Site Contaminant Query, January 2005, available at http://atsdr1.atsdr.cdc.gov

2. Arsenault, R. D. Pentachlorophenol and Contained Chlorinated Dibenzodioxins in the Environment. Amer. Wood Pres. Assoc. Meet. Proc. 72: 1976.

3. Becker J., Hopkins S., Jones A., Kiely T. A Qualitative Economic Impact Assessment of Alternatives to Pentachlorophenol as a Wood Preservative. U.S. EPA. Washington D.C. April, 2008

4. Belfroid A., Schoep P., Balk F. Addendum to the risk profile of pentachlorophenol. Royal Haskoning report for the ministry of VROM. Nijmegen, February 2009.

5. Borysiewicz M., Pentachlorophenol. Dossier prepared in support of a proposal of pentachlorophenol to be considered as a candidate for inclusion in the Annex I to the Protocol to the 1979 Convention on Long Range Transboundary Air Pollution on Persistent Organic Pollutants (LRTAP Protocol on POPs). Institute of environmental protection, Warsaw, May 2008.

6. Brimble, S., Bacchus, P. and Caux P.-Y., 2005. Pesticide Utilization in Canada: A Compilation of Current Sales and Use Data.

7. Brudermann G.Recommendations for the Design and Operation of Wood Preservation Facilities. Frido Consulting Report for Environment Canada, National Office of Pollution Prevention and Canadian Institute for treated wood. March 1999.

8. Canadian technical comments on Pentachlorophenol dossier. January 2009.

9. EPA. Preliminary Risk Assessment for Wood Preservatives Containing Pentachlorophenol Product chemistry: CDD/CDF impurities in technical grade pentachlorophenol, 3 May 2005, EPA-HQ-OPP-2004-402, available via http://www.regulations.gov

10. EPA. Hexachlorobenzene (HCB) as a Contaminant of Pentachlorophenol Ecological Hazard and Risk Assessment for the Pentachlorophenol Reregistration Eligibiltiy Decision (RED) Document, 3 May 2005, EPA-HQ-OPP-2004-402 available via http://www.regulations.gov.

11. EPA. Reregistration Eligibility Decision for pentachlorophenol. U.S. EPA report, september 2008, available via http://www.epa.gov/oppsrrd1/REDs/pentachlorophenol_red.pdf

12. EPA. Toxic Release Inventory. U.S. Environmental Protection Agency, available via http://www.epa.gov/triexplorer/chemical.htm

13. KMG. Company information, available via the webstie of KMG Bernuth http://www.kmgb.com/kmg

14. KMG. Material safety data sheets for penta-products, available via the website of KMG Bernuth http://www.kmgb.com/kmg

15. Morris P., Wang J., Wood preservation in Canada. Conference paper providing an overview of the Canadian Treated Wood Industry. Durability and Protection Group, Forintek

Canada Corp Forintek, 2006

16. Questionnaire on PCP, responses from UN-ECE member states and industry, gathered from January till March 2010.

17. Roewer J. USWAG Comments on Pentachlorophenol Revised Risk Assessments: Notice of Availability and Solicitation on Risk Reduction Options — No. EPA-HQ-OPP-2004-0402. June 2008.

18. Stephens R. et al. Draft Final Report, Wood Preservation Strategic Options Process. Socioeconomic Background Study. Carroll-Hatch (International) Ltd, North Vancouver, B.C. Prepared for Environment Canada Regulatory Economic Assessment Branch, March 1996.

19. UNEP United Nations Environment Programme. North America Regional Report regionally based assessment of persistent toxic substances, 2002.

20. UNEP United Nations Environment Programme. Pentachlorophenol and its salts and esters. Decision guidance document Rome-Geneva, 1991, amended 1996.

21. Wan, M. 1992. Utility and Railway Right-of-Way Contaminants in British Columbia: Chlorophenols. J. Environ. Qual. 21: 225-231.

22. WEI. Website of the European industry trade association representing the pressure treated wood industry, http://www.wei-ieo.org.

23. Zak, Jerry. Unique operational Characteristics of Creosote, Pentachlorophenol and Chromated Copper Arsenate as Wood Pole and Cross-Arm preservatives. GEI Consultants for USWAG. Glastonbury, April 2005.

Annex: responses to the questionnaire on PCP

Member state	Production	Consumption	Articles with PCP	Releases	Alternatives/technologies
Belgium	?	As pesticide:it was never authorized as pesticide in Belgium. As biocide: withdrawn authorization as biocide in 1987.	?	?	?
Canada	No, it stopped before 1990. PCP continues to be imported into Canada for use as a pesticide under the Pest Control Products Act	Use in telephone poles and pilings (90%), railroad ties, wood for construction (non-residential). The total amount is about 147 metric tonnes of which more than 150 tonnes per year are imported from the US. PCP imported for use into Canada is reviewed as part of the registration process under the Pest Control Products Act. Microcontaminant levels must remain consistent with product specifications filed and reviewed as part of the registration process. The use of Na-PCP for wood preservation stopped in 1981. Use of PCPL has never been registerd in Canada.PCP use must be consistent with the product label under the Pest Control Products Act. Wood treatment facilities must conform with the Technical Recommendation Documents for the Design and Operation of Wood Preservation Facilities (TRDs) which were negotiated with industry as part of the Strategic Options for the Management of CEPA-Toxic Substances lead by Environment Canada.	Utility poles and pilings (over 90%) as well as outdoor construction lumber with no residential use or no contact with food and drinking water (less than 10%) are placed on the market. Domestic furniture, textiles, paints, pallet boards, health care products with PCP are not placed on the market. No articles with PCPL or Na-PCP are placed on the market in Canada. Utility poles/pilings are buried in landfill sites approved for the disposal of toxic waste; some users separate outer treated surface from inner core to reduce waste quantity. Recycling options for treated utility poles were discussed with industry	No information	Environmental releases have been reduced to the extent possible by the utilization of the Technical Recommendation Documents, mentioned before. In the last 10 years, Environment Canada negotiated appropriate best practices for the design and operation of wood treatment plants using PCP as part of their technical recommendation documents for wood preservation plants to lessen the environmental impact of the treatment and use and disposal of treated wood with PCP.
Cyprus	No, never produced	No, never been used	No information	No information	Unclear
Czech Republic	No	?	No information	No information, although PCP is part of some monitoring programmes (waters, soils)	No information
Denmark	No, it stopped in the early 90's	No, only very very little for laboratories use: 50 g pr. year	No information	Unclear	Unclear
Estonia	No, never been produced	No, never used	No information	No information	No information
Germany	No, production stopped in 1986	No, it was used as fungizide (mostly in wood preservation) unti 1989.	No information. Potential sources for PCP are imported wood, textiles and leather articles because of higher or not existing thresholds in comparison with Germany (5 mg PCP/kg) and Austria. Some exotic types of wood (imported) and military articles are still potential sources of PCP. There is no recycling of PCP-containing articles => hazardous waste incineration	No information	Many alternative substances (organic and inorganic) are in use. Emission reduction from PCP-contaminated relicts (textiles, wood) through wastewater treatment.

Annex: responses to the questionnaire on PCP

Member state	Production	Consumption	Articles with PCP	Releases	Alternatives/technologies
Italy	Unclear.	Unclear. Council Directive 91/173/EEC of 21 March 1991 adds Pentachlorophenol in Annex I of the Directive 76/769/EEC on the approximation of the laws, regulations and administrative provisions of the Member States relating to restrictions on the marketing and use of certain dangerous substances and preparations.	No information	No information	No information.
Netherlands	No, in the 80's one producer was registered	No, the use of product containing PCP is prohibited in the Netherlands	The us of articles with PCP is prohibited	No information	Reference to UNEP Decision Guidance Document Pentachlorophenol and its salts and esters
Slovenia	No, never produced	No, never been used	No information	No information	No information
Spain	No, production stopped in 2003. Actions to restrict the PCP and its salts and esters on production were already taken.	No, the use of PCP as plant protecting product against pests stopped in 2003. Na-PCP was used for wood preservation. As plant protecting product against pests was forbidden in July 2003. PCP and its salts and esters can not be used in equal or higher concentrations than 0,1% weight in all substances and formulations commercialized. The use is restricted since 2003, but it could be commercilized, in an 0,1 per cent in weight in biocides from 01/01/2004. Currently there is no registration of plant protecting product containing PCP, neither in formulation for biocide applications . According to the Spanish National Implementation Plan, Na-PCP was used in the past for wood treatment applications. Actions to restrict the PCP and its salts and esters on use were already taken.	No information	PCP is included in the Spanish Pollutant Release and Transfer Register (PRTR-Spain). The available information of PCP is very limited.	PCP is included in the Spanish Pollutant Release and Transfer Register (PRTR-Spain). The available information of PCP is very limited. Scientific publications have reported the detection of PCP in ground water at low-mediun ng/L level (< 300) in Andalusia (Mezcua et al., J. Chromatogr. A 1109 (2006) 222-227) and in river sediments collected from an industrial area in Alicante (90 ng/g) (Llorca Porcel et al. J. Chromatogr. A 1216 (2009) 5955-5961).
Sweden	No, never produced	No, the use as wood preservative stopped in 1978	Imported domestic furniture and textiles	Reference to: IVL Swedish Environmental Research Institute Ltd. 2002. Screening av pentaklorfenol (PCP) i miljön. Report B 1474. (In Swedish with English summary)	Creosote, generally available

Annex: responses to the questionnaire on PCP

Member state	Production	Consumption	Articles with PCP	Releases	Alternatives/technologies
Switzerland	No. Production, import and use of PCP have been prohibited by law since 1986. This prohibition has been taken over in the Swiss Ordinance on Chemical Risk Reduction (ORRChem) since 2005. We have no information to whether PCP has ever been produced in Switzerland.	No, prohibited by law since 1986. Ban on wood-based materials cont. more than 5 ppm of PCP since 2006	Ban on wood-based materials cont. more than 5 ppm of PCP since 2006	No information	No information
Ukraine	No, never been produced. It Is included into the List of pesticides banned for usage in agriculture, registration and re-registration (Ministry of Health, 05.08.1997)	No, it is included into the List of pesticides banned for usage in agriculture, registration and re-registration (Ministry of Health, 05.08.1997)	No information	No information. The maximum residue limits for PCP in various media, as well as references on the corresponding analytical techinques are included into the State Sanitary Rules and Norms 8.8.1.2.3.4-000-2001 (Ministry of Health Protection).	No information
US	Yes, vulcan materials produced 1361 - 1815 tonnes in 2002	Yes, use for treatment of utility poles, lumber and timbers (construction), about 4,990 - 5,444 tonnes in 2002 of which 4,083 tonnes is imported.	Utility poles, about 34 million cubic feet (2002) and lumber and timbers, about 1 million cubic feet (2002)	In 2008 2585 kg total is released. Of this TRI reports 11 kg released to air, 510 kg released to water and 1860 kg deposited in landfills.	Chemical alternatives to pentachlorophenol wood preservatives include chromated arsenicals, creosote, copper and zinc naphthenates, ammoniacal/alkaline copper quaternary (ACQ), copper azole (CBA), sodium borates (SBX), and copper HDO (CX-A). Non-chemical alternatives include virgin vinyl, plastic wood composites, high density polyethylene, rubber lumber, concrete, fiberglass, steel, naturally resistant wood poles, and glass. Although many chemical and non-chemical alternatives exist for wood treated with pentachlorophenol, many are not truly interchangeable due to safety, environmental, efficacy, and/or economic considerations.

Annex: responses to the questionnaire on PCP

Stakeholder	Production	Consumption	Articles with PCP	Releases	Alternatives/technologies
PCP Taskforce	Yes. In the US KMG-Bernuth produces 7.257 tonnes in 2009 for the use as wood preservative, marketed to the US, Canada and Mexico.KMG-Beruth produced Na-PCP until 2006, when it stopped production of that product. KMG-Bernuth has never produced PCP laurate esters.	PCP is used to produce a concentrate for wood treatment by KMG-Benruth.	Utility Poles and Cross-arms (90% of market), Laminated beams for bridge construction (5% of market), Timbers for highway sound barriers (2% of market), Fence posts (2% of market), Research is ongoing to support railroad tie use. ecycling is part of the Memorandum of Understanding between USWAG and USEPA describes the agreement for management of out-of-sevice utility poles	The wood treatment facilities that use PCP have made significant modifications to their operations to reduce releases. The total industry releases to air and water as documented in the Toxics Release Inventory from 1988 to 2008 are illustrated.	Alternatives: The Comments on the Pentachlorophenol Revised Risk Assessment describes the issues around available alternatives. Process Changes: The graph attached in response to question 3a shows the effectiveness of process changes already put in place in reducing the releases of pentachlorophenol to the environment during the wood treatment process.
USWAG	No, never produced	PCP is not used by our organization or our members. Our members do used treated wood articles (utility poles and corssarms) treated according to federally-approved treatment standards with PCP	No information	No information	PCP treated wood poles serve a unique function in electric utility transmission and distribution networks. While there are some alternative materials to treated wood poles -- such as metal or concrete poles -- these alternatives do not offer a whole sale alternative to treated wood poles, including penta-treated wood poles. Our organization has conducted an in-depth analysis of the potential alternatives to PCP and other treated wood poles. This analysis concluded that there is no "one-to-one" substitutability with respect to preservatives for utility support structures and that there are no readily available substitutes that can effectively replace the PCP treated wood market in terms of functionality, effectiveness, availability and cost. A copy of the analysis, entitled "Unique Operational Characteristics of Creosote, Pentachlorophenol, and Chromated Copper Arsenate as Wood Pole and Cross-Arm Preservatives," (GEI Consultants, Inc, April 6, 2005), has been provided to the UN ECE.