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STOCKHOLM CONVENTION

Guidance on preparing inventories of PCP

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Guidance on preparing inventories of pentachlorophenol and its salts and esters

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**Secretariat of the Basel, Rotterdam and Stockholm
Conventions**

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1. Introduction

1.1 Pentachlorophenol (PCP) under the Stockholm Convention

On 17 May 2011, the European Union and its member States submitted a proposal to list pentachlorophenol (PCP) and its salts and esters (sodium pentachlorophenate, Na-PCP and pentachlorophenyl laurate, PCP-L) in Annex A, B and/or C to the Stockholm Convention (UNEP/POPS/POPRC.7/4). The proposal was considered by the Persistent Organic Pollutants Review Committee (POPRC) at its seventh meeting in Geneva in October 2011 (UNEP/POPS/POPRC.7/19), where the Committee deferred its consideration pending the receipt of additional information on the transformation of PCP to pentachloroanisole (PCA).

The Committee, at its eighth meeting, held in Geneva in October 2012 (UNEP/POPS/POPRC.8/16), decided, in accordance with paragraph 4 (a) of Article 8 of the Convention, and on the basis of additional information on the transformation of PCP to PCA presented at the meeting (UNEP/POPS/POPRC.8/INF/7) that, while the PCP molecule itself does not meet all the screening criteria specified in Annex D, PCP and its salts and esters meet the Annex D screening criteria, when its transformation into PCA is taken into account (decision POPRC-8/4). The Committee also decided, in accordance with paragraph 6 of Article 8 of the Convention and paragraph 29 of decision SC-1/7 of the Conference of the Parties to the Convention, to establish an ad hoc working group to review the proposal further and to prepare a draft risk profile in accordance with Annex E to the Convention, as well as, in accordance with paragraph 4 (a) of Article 8 of the Convention, inviting Parties and observers to submit to the Secretariat the information specified in Annex E.

At the ninth meeting of the POPRC, held in Rome in October 2013 (UNEP/POPS/POPRC.9/13), the Committee adopted the risk profile for PCP and its salts and esters (UNEP/POPS/POPRC.9/6), including consideration of the transformation product PCA. The Committee decided that PCP and its salts and esters are likely, as a result of their long-range environmental transport, to lead to significant adverse human health and environmental effects such that global action is warranted (decision POPRC-9/3). The Committee decided to establish an ad hoc working group to prepare a risk management evaluation that includes an analysis of possible control measures for PCP and its salts and esters in accordance with Annex F to the Convention and, in accordance with paragraph 7 (a) of Article 8 of the Convention, invited Parties and observers to submit to the Secretariat the information specified in Annex F.

At its tenth meeting, held in Rome in October 2014 (UNEP/POPS/POPRC.10/10), the Committee considered the draft risk management evaluation for PCP and its salts and esters (UNEP/POPS/POPRC.10/2) as well as comments and responses relating to it (UNEP/POPS/POPRC.10/INF/4). The Committee adopted decision POPRC-10/1, by which it adopted the risk management evaluation (UNEP/POPS/POPRC.10/10/Add.1) and decided, in accordance with paragraph 9 of Article 8 of the Convention, to recommend to the Conference of the Parties that it consider listing PCP and its salts and esters in Annex A to the Convention with specific exemptions for the production and use of pentachlorophenol for utility poles and cross-arms.

Taking note of the POPRC recommendation, the Conference of the Parties decided (decision SC-7/13) to amend Part I of Annex A to the Convention to list pentachlorophenol and its salts and esters with specific exemptions for the production and use of pentachlorophenol for utility poles and cross-arms and to insert note (vi) to reflect that pentachlorophenol (CAS No: 87-86-5), sodium pentachlorophenate (CAS No: 131-52-2 and 27735-64-4 (as monohydrate)), pentachlorophenyl laurate (CAS No: 3772-94-9) and pentachloroanisole (CAS No: 1825-21-4) are identified as persistent organic pollutants. Furthermore, each Party that has registered for the exemption for the production and use of PCP for utility poles and cross-arms is required to take necessary measures to ensure that utility poles and cross-arms containing PCP can be easily identified by labelling or other means throughout their life cycle. It is also required that articles treated with PCP should not be reused for purposes other than those covered by the exemption.

1.2 Purpose of the guidance

Under Article 7, paragraph 1 (a) of the Stockholm Convention, it is a mandatory requirement that all Parties develop and endeavour to implement a plan for the implementation of its obligations under the Convention. Furthermore, Article 15, paragraph 1 of the Convention requires each Party to report to the Conference of the Parties on the measures it has taken to implement the provisions of the Convention and on the effectiveness of such measures in meeting the objectives of the Convention.

To develop effective strategies for the elimination of PCP and its salts and esters (hereinafter collectively referred to as PCP) and the environmentally sound management of stockpiles and wastes containing those chemicals, Parties need to acquire a sound understanding of their national situation concerning its production, uses and releases. Such

information can be obtained through an inventory of generated PCP, materials and waste containing PCP and sites contaminated with PCP. The critical issues in developing an emission inventory are two-fold, firstly the availability of accurate and detailed information needed in development of inventories; and secondly the approach adopted to ensure the inventory is i) robust and defensible and ii) comparable to work of other nations also developing inventories. Therefore, the development of guidance documentation in this regard is of high value to support this work.

The purpose of this document is, therefore, to provide the necessary information and guidance to policy makers to enable them to fulfil their nation's obligations under the Stockholm Convention. Specifically, this guidance provides details in relation to three areas:

- (a) How Parties to the Stockholm Convention can develop inventories of PCP for their nation;
- (b) The chemical/non-chemical alternatives to PCP based on current uses; and
- (c) Effective policy measures that could be used to aid the phase-out of PCP and safe management of stockpiles of PCP and PCP treated goods.

1.3 Other guidance documents to be consulted

The users of this guidance should also consult *General guidance on POPs inventory development* (UNEP/POPS/COP.9/INF/19/Add.1) (UNEP, 2019) and other guidance documents to support review and updating of national implementation plans available on the website of the Stockholm Convention.¹

1.4 Objective of the inventory

The main objective of the inventory is to obtain information needed for the implementation of Parties obligations of the Stockholm Convention. More specifically, the objectives are to:

Establish a country baseline with respect to PCP production, use, stockpile, disposal and contaminated sites;

Provide the basis for development of a strategy in the National Implementation Plan (NIP) (i.e. identify the economic sectors that should be prioritized and the type of actions required for those sectors);

Report to the Conference of the Parties to the Stockholm Convention on progress made to eliminate PCP through national reporting; and

Identify areas where financial or technical support are needed (when resources are limited, to fulfil the obligations of the Convention).

The information obtained about PCP through the inventory includes the following:

- (a) Past and current production of PCP at the national level;
- (b) Intentional uses of PCP;
- (c) Import/export of PCP for use; or where relevant PCP treated timber;
- (d) Recycling practices of PCP containing products;
- (e) Alternatives to PCP available/used in the country;
- (f) PCP stockpiles and wastes, in particular relating to end of life treated timber;
- (g) Import/export of PCP containing waste for environmental sound destruction;
- (h) Sites identified as being potentially contaminated by PCP.

Information collected on the above will provide a broad understanding of the sources of PCP, the scope of their impacts and the risks that they pose to human health and the environment in a country. The information is important for Parties to evaluate whether they comply with obligations under the Convention regarding PCP and identify areas where they need to develop effective strategies and action plans for managing PCP in order to meet the obligations. This will be particularly relevant for management of goods treated with PCP, including end of life management issues.

¹ <http://chm.pops.int/tabid/7730/Default.aspx>.

Information collected as part of the inventory will also provide a valuable basis for Parties to report to the Conference of Parties on measures taken to implement the provisions of the Convention and the effectiveness of such measures (reporting under Article 15).

The inventory process is usually iterative. In establishing the inventory of PCP for the first time, Parties will also identify resources and technical capacity needed to further improve the accuracy of the inventory.

2. How to develop an PCP inventory

2.1 Introduction

Please refer to General guidance on POPs inventory development (UNEP/POPS/COP.9/INF/19/Add.1) (UNEP, 2019) for general approach to developing national inventories. The guidance describes general process to be taken in making an inventory. In summary, the following steps should be taken:

| |
|---|
| <p>Step 1: Initiating the inventory development process</p> <ul style="list-style-type: none">Establishing a national inventory teamIdentifying relevant stakeholdersDefining the scope of the inventoryDeveloping a workplanContacting the stakeholders <p>Step 2: Choosing data collection methodologies</p> <ul style="list-style-type: none">Indicative methodQualitative methodQuantitative method <p>Step 3: Collecting and compiling data</p> <ul style="list-style-type: none">Tier 1: Initial assessmentTier II: Main inventoryTier III: In-depth inventory <p>Step 4: Managing and evaluating the data</p> <p>Step 5: Preparing the inventory report</p> |
|---|

2.2 Step 1: Initiating the inventory development process

For general description of Step 1, please refer to Chapter 2.2 of General guidance on POPs inventory development (UNEP/POPS/COP.9/INF/19/Add.1) (UNEP, 2019).

In initiating the inventory development process, Parties are advised to establish a multi-stakeholder national inventory team. It is important to clearly define the responsibilities for national inventory team in developing the inventory as to streamline the work.

To define the scope of the inventory, the national inventory team should identify relevant stakeholders who will be contacted for the information in the process. Potential sectors and stakeholders involved in the life-cycle of SCCPs are listed in Table 1 below.

Table 1: Sectors and stakeholders involved in the production, use or impact of PCP

| Production | Stakeholders |
|--|--|
| General stakeholders | Ministry of environment and ministry of industry; Ministry responsible for waste management; NIP coordinator and steering committee; Basel Convention ² focal point (and stakeholders in Basel); Rotterdam Convention ³ focal point (and stakeholders in Rotterdam); Custom authorities; NGOs. |
| PCP production | Authorities granting production permits; Industry producing PCP; Waste management facility owners; Custom authorities. |
| Treatment of timber and non-timber products with PCP | Timber industry Authorities granting treatment permits; National infrastructure organizations such as utility companies; Waste management facility owners; Custom authorities. |
| Manufacturing of products/articles where PCP has been used | Textile industry; Laurate production industry; Na-PCP industry; Domestic property industry; Authorities granting treatment permits; Waste management facility owners; Custom authorities. |
| Use of PCP containing materials | Users/owners of treated timber or other products; Users of textiles contain laurate; Domestic users of Na-PCP; Ministry of Agriculture or Forestry and institutes and industries working with wood and treatment of wood; Ministry of defence; Ministry of business. |
| End-of-life treatment | Recycling companies (for textiles and treated wood waste); Housing demolition companies; Landfill owners. |

2.3 Step 2: Choosing data collection methodologies

There are a number of different approaches that have been used for gathering information for POPs inventories, i.e. indicative method, qualitative method and quantitative method. For more information on those methodologies,

² The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, hereby referred to as “The Basel Convention”, is an international treaty signed in 1998 that was designed to reduce the movements of hazardous waste between nations, and specifically to prevent transfer of hazardous waste from developed to less developed countries. As part of the wider work on ‘POPs’, the Basel, Rotterdam and Stockholm Convention share the same executive body.

³ The Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade, hereby referred to as ‘The Rotterdam Convention’, is an international treaty signed in 1998 that was designed to promote shared responsibility and cooperative efforts among Parties in the international trade of certain hazardous chemicals in order to protect human health and the environment from potential harm and to contribute to their environmentally sound use, by facilitating information exchange about their characteristics, by providing for a national decision-making process on their import and export and by disseminating these decisions to Parties.

please refer to Chapter 2.3 of General guidance on POPs inventory development (UNEP/POPS/COP.9/INF/19/Add.1) (UNEP, 2019).

Questionnaires are valuable instruments for primary data collection in inventory programs. Based on contact and consultation meetings with stakeholders, questionnaires with explanatory notes can be developed and sent to the relevant stakeholders to gather the information needed to compile data for a Tier II or Tier III assessment.

2.4 Step 3: Collecting and compiling data

For general description of Step 3, please refer to Chapter 2.4 of General guidance on POPs inventory development (UNEP/POPS/COP.9/INF/19/Add.1) (UNEP, 2019).

An initial assessment (Tier I) is carried out to obtain an overview of the relevant uses and stakeholders to be contacted in the key sector under investigation. Tier I methods usually rely on available literature and statistics in combination with calculations based on already existing information, such as the risk profile (UNEP/POPS/POPRC.11/10/Add.2) (UNEP 2015a) and risk management evaluation (UNEP/POPS/POPRC.12/11/Add.3) (UNEP 2016) adopted by the POPs Review Committee.

Main inventory (Tier II) will follow to generate data on the main sectors through interviews and questionnaires to the national stakeholders, and further identify missing information. This could also include actions such as desk study on pesticides storage facility contents.

If needed and resources are available, a more in-depth inventory (Tier III) can be initiated after evaluation of the data gathered in the main inventory.

The inventory team should investigate whether the following data exist in the country:

- (a) Former and current production of PCP;
- (b) Industries using or formerly using PCP;
- (c) Products and articles containing PCP in use/used;
- (d) Imports and exports of products and articles containing PCP;
- (e) Disposal practices for products and articles containing PCP when they become wastes;
- (f) Articles containing PCP that were recycled, the possible extent of recycling, and the types of articles produced from recycling, including the life cycle of PCP and its potential for emissions;
- (g) Stockpiles and wastes from current and former production and use in industries (countries that produced/produce PCP or used/use PCP in industries); and
- (h) Sites with activities that could have potentially contaminated the sites or environment with PCP.

It is desirable to collect and compile the following numerical data in the inventory:

- (a) Quantities of PCP formerly and currently produced, traded nationally and exported;
- (b) Quantities of products containing PCP (e.g. leather, textiles, treated timber, treated railway sleepers, treated products), recycled and quantities of products made from recycling;
- (c) Quantities of waste generated containing PCP; and
- (d) Quantities of PCP historically used in agriculture.

Data collection approaches will vary from country to country based on the data gathered in steps 1 and 2; they may be by estimations, using statistical data, industry provided data or possibly measurements.

The focal sectors to be investigated in the national inventory fall under following key areas:

- (a) PCP production;
- (b) PCP use for the treatment of timber, leather and other products;
- (c) PCP use in laurate manufacture;
- (d) Na-PCP use in the domestic construction sector;
- (e) PCP use in agriculture; and
- (f) Identification of contaminated sites and hot spots.

In addition, data collected for the first four areas will form the basis for the preliminary inventory of contaminated sites and hot spots.

2.5 Step 4: Managing and evaluating the data

For general description of Step 4, please refer to Chapter 2.5 of General guidance on POPs inventory development (UNEP/POPS/COP.9/INF/19/Add.1) (UNEP, 2019).

The compiled data (draft inventory) should be assessed by stakeholders and possibly by an external expert. Depending on the feedback, further information may need to be gathered.

2.6 Step 5: Preparing the inventory report

The final stage of the inventory is preparation of the inventory report. This report includes results of inventories of all key sectors investigated by the country compiled in a single document.

The essential elements of the report are:

- Objectives and scope;
- Description of data methodologies used and how data were gathered, including all the assumptions and conversion factors adopted as a result of expert judgment;
- Final results of the inventory for each sector considered a priority for the country (using a format to be provided in this guidance, as such or adapted from that format);
- Results of the gap analysis and limitations identified for completion of the inventory;
- Further actions (e.g. stakeholder involvement, data collection strategies) to be taken to complete the inventory and recommendations.

Other information (e.g. stakeholder list) could be included in the report depending on the national preferences.

3. Information on PCP

3.1 Production of PCP

3.1.1 Description of the characteristics of PCP

The following information taken from the PCP risk profile (UNEP/POPS/POPRC.9/13/Add.3) provides a brief overview of the physical data held for PCP its salts and esters under the Stockholm Convention.

Table 2: Chemical Structures

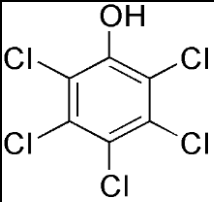
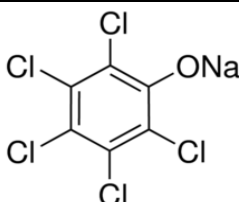
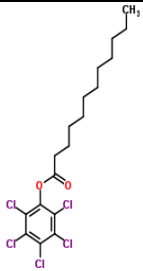
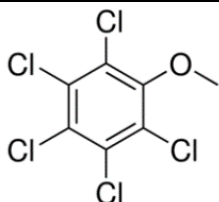
| | Pentachlorophenol | Sodium pentachlorophenate | Pentachlorophenyl laurate | Pentachloroanisole |
|---|---|---|--|---|
| Molecular formula | C ₆ HCl ₅ O and C ₆ Cl ₅ OH | C ₆ Cl ₅ ONa and C ₆ Cl ₅ ONa x H ₂ O (as monohydrate) | C ₁₈ H ₂₃ Cl ₅ O ₂ | C ₇ H ₃ Cl ₅ O |
| Molecular Mass | 266.34 g/mol | 288.32 g/mol | 448.64 g/mol | 280.362 g/mol |
| Structural formulas of the isomers and the main transformation product |  |  |  |  |

Table 3: Physical and chemical properties of pentachlorophenol and pentachloroanisole

| | Pentachlorophenol | Pentachloroanisole | |
|---|---|--|--|
| Properties | Value ¹ | Value | Reference |
| Water solubility 25°C | 0.13% (% weight) 5 mg/L at 0°C ^{1,2} 14 mg/L at 20 °C ^{1,2} 35 mg/L at 50 °C ^{1,2} 14 mg/L at 25 °C ^{1,2} | <1 mg/L 0.24 mg/L 0.19 mg/L | http://cameochemicals.noaa.gov/chemical/20850 EVA method logK _{ow} method |
| Vapour pressure (25°C) | 2 mPa (20 °C) 0.0070-0.213 Pa (25 °C) 1.1 x 10 ⁻⁴ mm Hg (25 °C) ² Intermediate volatility | 0.0458 Pa (25 °C) 0.0933 mm Hg Intermediate to high volatility | Modified Grain Method Dobbs and Grant (1980) Kennedy and Talbert, 1977 classification scheme |
| Henry's law constant atm/m ³ /mol | 2.45x10 ⁻⁶ atm.m ³ /mol ² 0.0248 to 0.284 Pa m ³ /mol | 1.94x 10 ⁻³ atm-m ³ /mole (25 °C) (Group method) (1/H = 12.7, K _{AW} = 0.003) 7.12 x 10 ⁻⁵ atm-m ³ /mole (25 °C) (Bond method) | HENRYWIN v3.2 in U.S. EPA 2011 |
| | Potential to volatilise from water or moist soil | Potential to volatilise from water or moist soil | Mackay and Wolkoff, 1973 classification scheme |
| Dissociation constant (pK _a) | pKa 4.60-5.30 pKa 4.7 ² At neutral pH of most natural waters, PCP is more than 99% ionised. | Not expected to dissociate under environmentally relevant pH. | - |
| Log Octanol/water partition coefficient (LogK _{ow}) | The measured values are between 1.3 and 5.86 and the value appears to be pH dependent. Generally accepted values are 5.12 and 5.18 Potential to bioaccumulate in biota | 5.30 (modelled) 5.45 (laboratory) Potential to bioaccumulate in biota | KOWWIN v1.68 in U.S. EPA 2011 Opperhuizen and Voors (1987) |
| K _{oc} | 293 to 900 L/kg(at 0.0125 mg/L) | 2474 L/kg | MCI method, KOCWIN 2.0 |
| | 1000 L/kg (calculated) | 13800 L/kg | K _{ow} method, KOCWIN 2.0 in U.S. EPA (2011) |
| | 3000 to 4000 L/kg (measured) 293-4000 L/kg ² 706-3420 L/kg (measured) ² Slight mobility to moderate mobility in soil | Immobile | McCall et al., 1981 classifications scheme |

3.1.2 PCP as a source of dioxins and furans

Polychlorinated dibenzo dioxins and furans (PCDD / PCDF) are a family of chemicals, which, because of their physical properties and toxicity, represent a risk to human health and the environment. Such are the concerns for these substances that they were two of the twelve POPs targeted by the Stockholm Convention since its entry into force in 2004, with a listing in Annex C. While dioxins and furans have no known commercial use, they are created unintentionally by a number of activities, with combustion in particular an important pathway for the generation and release to environment of dioxins and furans.

Dioxins and furans are by-products in the manufacturing process used to produce PCP, which means that PCP products contain a number of unintended contaminants, including dioxins and furans. This means that when PCP is

produced, used, and when PCP-articles are used or disposed of as waste, PCP and its contaminants (including dioxins and furans) are released into the environment (UNECE, 2010). Additionally the UNECE (2010) and Environment Canada (2004) both highlight the risk of combustion for treated PCP timber as an emission source for dioxins and furans, with further data on emission estimates. This will be of particular concern for low temperature, incomplete combustion processes such as bonfires or open burning of waste wood treated with PCP products.

As dioxins and furans are listed in Annex C to the Stockholm Convention, there are obligations placed upon Parties to develop and report source inventories and release estimates for these substances, and to take action to minimise and ultimately eliminate their release. This guidance document is intended to aid the reader with work in the development of inventories for PCP its salts and esters. However additional guidance on the development of estimates for dioxins and furans within PCP and PCP products is available within the UNEP Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases (UNEP 2013e). This includes default emission factors to quantify dioxins and furans within PCP and PCP based products.

3.1.3 Intentional production and trade of PCP

PCP has been produced commercially and used as a wood preservative since the 1930s. PCP can be manufactured by three main routes: by the chlorination of phenol at high temperatures in the presence of various catalysts, by an alkaline hydrolysis of hexachlorobenzene (HCB), or by thermolysis of hexachlorocyclohexane (HCH) (Choudry et al., 1986; IEP, 2008; UNEP, 2013). Na-PCP and PCP-L in turn are produced using PCP as a starting material (OSPAR, 2001; German Federal Environment Agency, 2015).

Historically PCP or Na-PCP have been produced at least in Brazil, China, former Czechoslovakia, Denmark, France, Germany, Poland, Spain, Switzerland, former USSR and the United Kingdom (UNEP 2017b). In the European Union (EU) production of PCP and its salts stopped in 1992, while production of PCP-L continued until year 2000. PCP-L has been produced at least in China and the United Kingdom. PCP containing tetrachlorophenol formulation Ky-5 used in Finland and Sweden was produced between 1940 and 1984. In Brazil, production of PCP and Na-PCP started in 1966, and it was banned in 2006; the total production was estimated at 10,600 tonnes of PCP, 27,900 tonnes of Na-PCP until 1978 (Castelo Branco, 2016). Na-PCP was also produced in Chapaevsk, Samara region, Russian Federation, with annual capacity of 2,400 tonnes (Kluev et al., 2001).

At the height of its production, global output of PCP was around 90,000 tonnes per year (IEP, 2008). The Economist Intelligence Unit (1981) estimated world production to be of the order of 50 000-60 000 tonnes per year, based on the North American and European Community output (UNEP, 2011c). However, by the 1990s, widespread use of PCP was discontinued in most countries (UNEP, 2013d). Currently, PCP has either no uses or is banned in all EU Member States, Australia, China, India, Indonesia, New Zealand, Russia and Switzerland, and is used only in the USA and Canada (Amec Foster Wheeler, 2006).

PCP and its salt and esters are currently produced only in Mexico and in India, with formulation also taking place in the USA. US chemical company KMG Chemicals Inc. is reported to be the only producer of wood treating PCP in the world (under the commercial name 'Penta'), with a production facility in Matamoros, Mexico and a formulation facility in Tuscaloosa, Alabama, USA (UNEP, 2014c).

It is reported that the KMG plant in the USA formulated 7,257 tonnes of PCP (liquid concentrate) in 2009, marketed for wood preservation purposes in the USA, Canada, and Mexico (UNECE, 2010). No data are provided by the company on the quantities of solid PCP produced in Mexico and shipped to the USA for formulation. However, the Mexican Government reported a similar level of production for 2009 (6,610 tonnes). Mexico reported that 3,670-7,343 tonnes of PCP were exported yearly between 2007 and 2011 to the USA, Colombia and Peru. Mexico also reported imports of PCP from the USA, China and Germany between 1997 and 2011 (UNEP, 2013d). Canada reported that 372-537 tonnes of PCP were imported yearly from Mexico between 2008 and 2012 (Canada, 2014). The USA reported that in 2002, 4,083 tonnes were imported and 1,361-1,815 tonnes were produced domestically (USA, 2014).

The industry association Indian Chemical Council (ICC) reports that Na-PCP is also used in India mainly as a wood preservative but also for the preservation of water-based 'distemper paints' while in storage, with 1,800 tonnes per year of Na-PCP being produced in the state of Maharashtra and West Bengal, India (ICC 2014).

Production of PCP and Na-PCP ceased in the EU in 1992. However, beyond this date these chemicals continued to be imported to the European market from the USA. In 1996 a total of 378 tonnes of Na-PCP and 30 tonnes of PCP were imported into the EU (OSPAR, 2004). Of the 378 tonnes of Na-PCP imported to the EU, the three principal importers were France (126 tonnes), Portugal (108 tonnes) and Spain (144 tonnes). 30 tonnes of PCP were imported to the EU in 1996, 28 tonnes of which were synthesised to 46 tonnes PCP-L in the UK. Of the 46 tonnes of PCP-L produced, 5-

10 tonnes were exported to France and a similar quantity was used in the UK. The rest was exported to countries outside the EU (OSPAR, 2004).

PCP and its salts and esters are subject to a number of agreements, regulations and action plans that restrict its production, trade and use in many countries. PCP is listed in Annex III of the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade, and is, therefore, subject to a legally-binding prior informed consent (PIC) procedure, with more than 130 Parties to the Rotterdam Convention. In 2014, PCP (as well as Na-PCP and PCP-L) were included in Annex A to the Stockholm Convention on Persistent Organic Pollutants.

The Oslo Paris Convention for the Protection of the Marine Environment of the North-East Atlantic (the "OSPAR Convention") is currently signed by 15 European Atlantic countries and the EU controlling the dumping of hazardous materials. OSPAR gave priority to PCP in its 1992 Action Plan and it was included in the 1998 OSPAR list of Chemicals for Priority Action (OSPAR, 2004).

Harmonised EU legislation restricts the use of PCP as a substance or in mixtures, but some European countries – including Norway, Denmark, Germany, Netherlands and Austria – have implemented additional restrictions to the import and marketing of consumer products containing PCP. As such, consumer goods treated with PCP may not be placed on the market in these countries if they contain more than 5 mg/kg of PCP and its salts and esters (OSPAR 2004).

3.2 Intentional uses of PCP

PCP is a general biocide and has been used extensively as a fungicide, bactericide, herbicide, molluscicide, algacide, insecticide, disinfectant, defoliant, anti-sapstain agent and anti-microbial agent in various industries including agriculture, textiles, paints, oil drilling and forestry (UNEP, 2013d).

The major worldwide use of PCP, since it was first produced in 1936, has been as a heavy-duty wood preservative, used for utility poles and pilings, railway ties, outdoor construction materials and as a remedial treatment of timber and as a surface biocide for masonry (UNEP, 2013d). This is carried out to protect freshly-felled wood from attack from organisms that could undermine its structure, or stain or discolour the wood, thus reducing its commercial value (OSPAR, 2004). Treatment is used for example when timber in industrial or domestic premises repeatedly becomes wet or stays wet and, therefore, is susceptible to decay by wood-rotting fungi (OSPAR, 2004).

Historically, PCP has also been used in rice and sugar cane production, in water treatment, as a pre-harvest defoliant in cotton, and as a general pre-emergence herbicide (USEPA, 2008a). PCP has also been utilized in a number of products including leather and paper (USEPA, 2008a) and as slimicide in pulp and paper production. Furthermore, PCP has also been used for the production of pentachlorophenyl laurate (PCP-L).

PCP-L is used in the preservation of textiles and fabrics, particularly those used in heavy-duty military applications, which are subject to attack by fungi and bacteria during storage and use. These include wool, cotton, flax and jute fabrics and yarns used in covers, tarpaulins, awnings, tents, webbing, netting, sails and ropes (OSPAR, 2004).

Sodium pentachlorophenate (Na-PCP), was also used as a pesticide, namely as a molluscicide, for similar purposes as PCP in industrial wood preservation.

PCP (Na-PCP and PCP-L) has previously been used in the past also for instance as preservative in oil-based paints, as preservative in glues (leather, toilet paper etc.) and in adhesives, as an intermediate product for the synthesis of pharmaceuticals, as an intermediate product in obtaining colouring substances (anthraquinon colorants and intermediates), for wooden trays used in mushroom farms, in slime control in pulp and paper production and as an agricultural chemical in weed control (OSPAR, 2004).

PCP is currently allowed worldwide only for wood preservation uses. Regarding its salts and esters, in addition to Na-PCP use in India for preservation of wood and paint products during storage (ICC 2014), Mexico also reported in their response to Annex E questionnaire registered uses in wood preservation, adhesives, tanneries, paper manufacture and textile manufacture for Na-PCP. However Mexico has now clarified that wood preservation is the only use authorised and that it is not aware of any other active uses (Mexico 2014).

The Canadian response to the Annex F questionnaire reported that PCP is registered for the treatment of wood for utility poles, cross-arms, outdoor construction materials, pilings and railway ties, although it indicated that PCP-treated railway ties have not been installed since 1993 (Canada 2014). Canada has reported an increase of the amount of PCP used, from 372 tonnes in 2008 to 537 tonnes in 2012 (Canada 2014).

The USEPA reported that in 2002, approximately 4,990-5,444 tonnes of PCP were used for utility poles, lumber and timbers in the USA. According to a USA EPA report (USEPA 2008b), there is an estimated 130–135 million

preservative-treated wood utility poles in service in the USA, representing over 90% of the pole market and presenting a replacement rate of 2 to 3% (approximately 3-5 million poles) per year (USWAG [as cited in IEP, 2008]). According to (Troyjanskaja, 1999) in the former USSR at the timber enterprises of Arkhangelsk 5700 tons of Na-PCP were used from 1959 to 1987, which is 64% of its total consumption in the region. Uses in other countries are not known (UNEP, 2013d)

Na-PCP was used in India, mainly for wood preservation purposes-impregnated wood/ particle boards. In the USA and Canada PCP was only allowed as a heavy-duty wood preservative for industrial use, primarily for the treatment of utility poles and cross-arms, which account for more than 90% of PCP-consumption in those countries with the remainder being wood treated for other uses (laminated beams for bridge construction, sound barriers, fence posts and railway sleepers) (UNECE 2010).

The main use of PCP in the OSPAR region was the production of PCP-L. This had been carried out by one plant in the UK (OSPAR, 2004). No country has reported use of PCP-L (within the Annex F survey).

The use of PCP (and Na-PCP and PCP-L) is restricted by a number of national and international legislative measures (Cooper and Radivojevic, 2012).

For all EU Member States, the use of PCP was restricted in 1991 by Council Directive 91/173/EEC, which prohibited the marketing and use of PCP at a concentration greater than 0.1 %. Restrictions on the use of PCP and its salts and esters were tightened by Commission Directive 1999/51/EC, meaning all uses of PCP including wood preservation were officially terminated at the end of 2008.

According to Annex XVII to the European Regulation (EC) No. 1907/2006 of the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), PCP and its salts and esters shall not be placed on the market or used as a substance; as a constituent in other substances, or in mixtures, in a concentration equal to or greater than 0.1 % by weight.

Additionally, PCP is not included in the list of authorised substances permitted for use in plant protection products and biocide products under Regulations EC 1107/2009 and EU 528/2012 respectively, meaning such products containing PCP thus should be withdrawn PCP is also prohibited for use in cosmetic products under Regulation EC 1223/2009.

The European Union's Integrated Pollution Prevention and Control Directive (IPPC Directive) 96/61/EC and the new Directive 2010/75/EU on industrial emissions (integrated pollution prevention and control) cover emissions and discharge of installations dealing with treatment of PCP containing material (UNEP, 2014b).

A number of countries also prohibit or limit the production, trade and use of PCP (Na-PCP and PCP-L) through national legislation or other measures. This includes a number of OSPAR countries including Austria, Denmark, Finland, Germany, the Netherlands, Norway, Sweden and Switzerland (OSPAR, 200b) as well as Japan, Australia, India, Indonesia, New Zealand, Russia, Thailand, Belize, Nigeria (UNEP, 2013b).

Countries such as the United States and Canada have implemented regulatory measures to minimise worker exposure to PCP and minimize environmental releases at treatment facilities and disposal. In both countries, various authorities are involved in the regulation of air emissions, storm water, waste water and control of soil wastes (collection, transportation, handling, storage, treatment, use, diversion, recycling, re-use, recovery, reduction or disposal). Burning of treated wood is not permitted in either country (UNEP, 2014b).

In the United States, PCP is restricted to the treatment of utility poles, lumber and timbers (construction). The industry is heavily regulated and US states have a well-developed approach to managing treated wood and other wastes. They identify different well-defined landfill types with prescriptions of whether treated wood waste can be disposed there and generally provision for incineration for energy subject to meeting air emission requirements (UNEP, 2014b).

In Canada as of 1990, PCP is only used as a heavy-duty wood preservative to treat primarily electrical utility poles and cross-arms. It is also used on posts and industrial construction timbers. PCP can only be used in specialised facilities compliant with appropriate technical guidance for the design and operation of wood preservation facilities (UNEP, 2014b).

3.3 PCP in stockpiles, products and waste

The generation of wastes and stockpiles containing PCP will depend on the management of the (former) uses of PCP and on the management of the PCP unintentionally generated. Production and use of PCP in industrialised countries was at its peak between the 1970s and 1990s, before increasingly stringent legislation resulted in the use of PCP being reduced significantly in more recent years. Use of PCP is still ongoing in a number of countries.

However, based on review of the major uses of PCP based products the likely major stockpiles will be dominated by:

- (a) Treated wood and what type of wood (timber in constructions, utility poles, railway sleepers, etc.);
- (b) Treated leather;
- (c) Treated textiles (but shorter lifetime).

Alongside the issue of stockpiles, many sites exist that will be contaminated from the historical use of PCP and from improper practices (e.g. at former production plants and wood treatment facilities prior to the implementation of strict regulations). These sites will continue to be sources of PCP in the environment (Wild et al., 1992). Releases to the environment may also occur through revolatilization from adsorbed residues of PCP/PCA, either from surfaces to which PCP has been applied (e.g. treated wood) or soils/sediments where waste wood has been disposed.

PCP-treated wood contains substantial quantities of the compound. The World Health Organisation (WHO) (1987) detail a number of studies that report highly elevated PCP levels in wood products (e.g. wood shavings used for livestock litter, PCP-treated wood used in furniture, wood panelling etc.) compared with untreated wood. For example, Gebefuegi et al. (1979) measured PCP concentrations for furniture treated with PCP and compared with untreated wood samples. The top (0 - 1.5 mm) layer of treated wood contained 1,570-2,754 mg/kg PCP, compared with 15.5 to 26 mg/kg in the untreated wood.

The concentrations of PCP in waste wood are difficult to determine and will be highly variable because they depend on the original application rate, the age of the wood and the kind of use of the wood (Pohlandt et al., 1995). Pohlandt et al. (1995) investigated 214 samples of waste wood, including wood packings, pallets, interior decoration, beams, windows, fences, stakes and cable-drums. Countries of origin of the wood packings were among others Argentina, Germany, India, Italy and Spain. In most samples of raw wood, PCP concentrations were below the determination limit of 0.05 mg/kg. The highest PCP content amounted to 0.25 mg/kg. Furthermore, wood packings, pallets, beams, fences, stakes and cable-drums show low PCP concentrations. PCP was only detected at measurable levels in four of the thirty-nine wood packings and pallet samples. However, with regard to recycling chips, where it is likely that treated waste wood was used, the highest analysed PCP concentration was 4.43 mg/kg. Relatively high levels of PCP were also found in the wood of interior decoration and windows. In only four of sixty-eight window samples PCP was not detectable.

As discussed in Chapter 3.1.2, PCP has been used in, or in the production of a number of products for domestic, consumer or household application, including paints, glues, paper and textiles. On the basis of the diverse applications of PCP, it could be expected that a large number of products contain this compound. However, there are few data on PCP levels in these products (WHO, 1987).

Given the relatively short lifespan of these consumer and household products, it could be expected that a large proportion of the PCP that has been used or contained in these products will have now passed to a waste stream. As discussed in Chapter 3.1.2, many countries now impose restrictions or have banned the use of PCP in most applications other than in wood treatment, so it could also be expected that the levels of PCP contained within products will continue to decline.

3.4 Sites potentially contaminated by PCP

Soil contamination can be an issue at wood preservation facilities if no effective measures are in place (Environment Canada, 2013). Contaminated soil can be spread by vehicles and wind, but it will mostly migrate into runoff water and can potentially contaminate drinking water. Adsorption of PCP to soil is influenced by soil pH and organic carbon content with adsorption generally increasing as soil pH decreases (Environment Canada, 2013). Leaching of PCP tends to increase with high PCP input, high soil moisture, alkaline soil conditions and low organic matter content in the soil (Kaufman 1976 [Cited in Environment Canada 2013]). Over a range of temperatures and pH, the solubility of PCP in the ambient environment was found to vary from 5 to 8000 mg/L.

Contaminated sites such as former PCP production plants, and wood preservation plants may continue to be major sources of PCP to the environment (OSPAR, 2004). Additionally, where PCP contains micro contaminants including dioxins and furans, former sites of PCP production will act as a source for these substances too. In the future it is likely that gross contamination at sites currently producing or using PCP such as wood treatment sites will decline due to reductions in use. However, PCP levels in the non-exposed environment may rise in the short term due to recirculation from contaminated sites, meaning these contaminated sites will act as a source of PCP to the surrounding environment. PCP concentrations in the general environment could therefore lag behind reductions in PCP use (Wild et al., 1992).

Soil contamination is generally confined to areas in which wood treatment with PCP is carried out now or has been in the past. In these areas, concentrations may stay high for a long time because of slow degradation in the soil. Degradation in the soil depends on the concentration of the substance, presence of acclimatised bacteria, aerobic/anaerobic conditions, organic matter, pH, nutrients, humidity and temperature. Depending on the soil type, PCP can be very mobile, leading to groundwater contamination.

Data on 154 soil contamination cases were gathered in a Finnish register by environmental authorities in 1992 (Ministry of the Environment 1994 [as cited in OSPAR, 2004]). Two third of the cases were sawmills. In almost all cases the soil had been polluted, but 32 of the cases also illustrated high groundwater concentrations in the immediate vicinity of where the original facility had been based. High concentrations of contaminants were also observed from surface water and air. The volume of heavily contaminated soils (for example more than 4 mg/kg PCP) which needed immediate treatment was 720 m³. Volume of less contaminated soil, where no immediate actions were required (0.4 mg/kg to 4 mg/kg PCP) was 15 000 m³. Since this inventory was completed these figures have increased. High PCP levels in sawmill areas and wastes have been measured. McNeill (1990) reported the effects of 2 major spillages of wood preservative at a Scottish sawmill/timber treatment plant. Two incidents occurred in 1983, which resulted in the saturation of an area of 50 m² of soil. There was also runoff, contamination of groundwater and the receiving burn and river. In addition to the spillages, poor treatment practices i.e. runoff from stacked timber, contributed to the overall contamination of the soil (ACP 1994).

Similar cases are likely to exist in other countries. In addition to contaminated soil and possible leaching to groundwater, discharges to rivers and sea are also possible. During cleaning of contaminated soil there are also likely to be emissions to air.

On the territory of Russian Federation in the Arkhangelsk region, the use of Na-PCP for processing of wood for several decades led to the contamination of industrial sites and adjacent territories with PCDD/PCDF, HCB, PCP (Veliamidova, 2012). Fifteen years after the end of the application of Na-PCP, residual amounts of pentachlorophenol were widely found in soils at a fairly high level of content - from 0.9 to 1160 mg/kg. According to the data (Troyanskaya, Veliamidova, 2009), the content of PCDD and PCDF in soil at one of the timber processing sites was 196-449 µg TEQ/kg. It was established that the soil was polluted to the depth more than 1 m. Pollution of bottom sediments of the Onega river basin with chlorinated organic compounds under the influence of historical usage of Na-PCP for wood preservation is shown (Troyanskaya, Veliamidova, 2007).

Detailed below are selections of PCP contamination case studies.

Pentachlorophenol Contamination of Private Drinking Water from Treated Utility Poles, Vermont, US (Karlson et al, 2013)

In 2009, the Vermont Department of Health and state partners responded to 2 cases of private drinking water contamination with pentachlorophenol (PCP). Both were attributed to ingress of PCP to the water table from newly installed utility poles in the vicinity of the local water source.

In the first case, the water was from a shallow dug well and had a PCP concentration of 2.06 milligrams per litre, and a subsequent sample had a concentration of 1.15 milligrams per litre, respectively about 2,000 and 1,000 times the EPA maximum contaminant level (0.001 mg/L).

In response, the Vermont Department of Environmental Conservation and the utility company were contacted to coordinate a clean-up. The utility company replaced the poles with non-treated cedar poles and paid for a new 705-foot drilled well to be installed.

In the second case, the water was from a private spring. When a sample was taken; it had a PCP concentration of 0.007 milligrams per litre, and a subsequent sample had a concentration of 0.002 milligrams per litre, both of which were above the EPA maximum contaminant level.

Again, the utility company replaced the poles with non-treated cedar poles and paid for a point-of-entry charcoal filtration system to be installed allowing the water to be used. Within three months of the replacement of the poles, PCP was not detected in samples collected directly from the spring.

National Wood Preservers Site, Delaware County, Pennsylvania, US (USEPA, 2017)

From 1947 to 1991, National Wood Preservers ran a wood treatment operation at a site in Delaware County, Pennsylvania. The site has been characterised and it was found that groundwater and several soil areas were contaminated with PCP, arsenic, dioxins, volatile organic compounds (VOCs), and petroleum hydrocarbons. Contamination of the local groundwater is thought to be partly due to the operations undertaken, but also due to the operator disposing of liquid wastes, thought to contain PCP, in a well leading to groundwater under the plant.

Detailed site characteristics are not available, but the clean-up operation is ongoing and has been extensive. A summary of the clean-up operation is provided below.

In 1976, the EPA performed various remedial actions to contain the contamination and the site was listed on the National Priorities List for federal clean-up.

In 1987, the EPA put up a fence around the property to restrict access to the site and sponge-like barriers and a catch basin were installed in Naylor's Run (a small local stream) to contain chemicals.

In 1992, the EPA removed tanks and drums from the facility in which about 97,000 tons of liquids, 55 gallons of solids, and 60 tons of sludges – all containing hazardous wastes – were disposed of off-site.

In 1996, a three-acre synthetic cap was installed over the areas of contaminated soil in the vicinity of the source area, eliminating the threat of potential exposure.

Since August 2001, a groundwater treatment plant has been successfully operating full time and removing contamination from the shallow groundwater.

In May 2003, the EPA discovered an abandoned sewer line transferring contaminated groundwater to a Residential Open Space (ROS) Area. The sewer line was properly cleaned and sealed.

In the summer of 2005, EPA surveyed the area to determine property lines along Naylor's Run, sampled soil and groundwater, and assessed the extent of the contamination caused by the leaking abandoned sewer line.

In August 2005 the EPA completed its third five-year review of the site. The EPA found that there has been no new or recent exposure to site soils or groundwater.

In April 2006, two additional extraction wells were added to the treatment facility.

In April 2006, the EPA finished construction of two more extraction wells which extract the contaminated groundwater from the deeper aquifer and transports it to the treatment system.

In March 2007 the Remedial Investigation of the deep groundwater soils and sediments of Naylor's Run as well as the ROS area were finalized, and in August 2007 the Feasibility Study was finalized.

In August 2007 the EPA issued the Proposed Plan for the Site and conducted a public comment period.

The Record of Decision for the deep groundwater, soils and sediments of Naylor's Run and the ROS area was signed on April 16, 2008.

In 2009, the EPA used \$3.2 million in American Recovery and Reinvestment Act (ARRA) funds to remove contaminated soil from residential properties and from an ROS area, to improve the performance of the groundwater treatment system, and to install additional groundwater extraction wells.

The Site reached construction completion on September 16, 2010. The groundwater continues to be extracted and treated on a continuous basis.

In September 2009 the EPA completed its fourth five-year review of the site and found that the site is protective in the short-term because the groundwater extraction and treatment facility is operating as intended, the multi-layer geotextile cap prevents contact with contaminated soil in the Source area and the excavation and off-site disposal of the soils from the Recreation and Open Space area prevent exposure to contaminated soil in that portion of the site.

The EPA is currently conducting the fifth five-year review for the site.

Cedar Service site, Northeast Minneapolis, Minnesota, US (ATSDR, 2006)

The Cedar Service site in Northeast Minneapolis, Minnesota was contaminated with wood treatment products from a former wood treatment operation, primarily pentachlorophenol (PCP), polynuclear aromatic hydrocarbons (PAHs), and dioxins/furans. Residual contaminated soil remains at the site at depth and is also present at the surface in some areas, although exposure is likely minimal. Groundwater is heavily contaminated with PCP on- and off-site.

The site was operated from 1926 to 1972 and was used for wood treating operations using creosote (until the mid-1960s) and later pentachlorophenol (PCP) mixed with fuel oil. The company used a variety of steel-lined concrete tanks and vats for their operations in a main process area on the western part of the site. Treated wood was typically shipped out to customers by rail, and not stored on site.

Around 1961, it was reported that approximately 30,000 gallons of PCP wood treatment fluid were spilled when a truck accident caused a pipe rupture at the PCP pump house located at the southern end of the wood treatment area. The spilled PCP reportedly flowed south toward a low area. Details regarding the spill and the response to it are not available. Cedar Service, Inc. ceased operation at the site in 1972, and the structures associated with the

operation were demolished in 1973. Cedar Service, Inc. reportedly buried between 8,000 and 10,000 gallons of wood treatment sludge on the property. The former main process area remains vacant.

Soil Investigations and remediation

The first large-scale investigation at the site was conducted in 1995 and found soil contamination in two distinct areas: the former process area and a small fill area located just north of the former process area.

Shallow soils (less than 10 feet deep) were found to be contaminated with PCP at concentrations as high as 1,300 mg/kg and total PAH concentrations were as high as 1,000 mg/kg.

Soil samples from the deeper soil borings (10 to 34 feet below ground) showed lower concentrations of PCP and total PAHs, with maximum values of 22 mg/kg and 75 mg/kg respectively.

Soil samples collected from below the water table (at depths greater than 34 feet) also showed contamination, with PCP levels as high as 250 mg/kg and total PAH concentrations as high as 630 mg/kg. Concentrations of petroleum-related VOCs were lower.

The above values generally exceed soil evaluation criteria developed by the Minnesota Pollution Control Agency (MPCA) known as Soil Reference Values (SRV) and Soil Leaching Values (SLVs).

The SRVs represent the concentration of a contaminant in soil at or below which normal dermal contact, inhalation, and/or ingestion are unlikely to result in an adverse human health effect.

The SLVs represent the concentration of a contaminant in soil above which leaching could contaminate the groundwater to levels above established standards.

In 1997, approximately 12,200 tons of contaminated soil were excavated and removed from the site for transport (by rail) to an out-of-state land disposal facility. Confirmatory testing did show some areas of PCP contaminated soil (up to 400 mg/kg) remained at depths of 12 feet but the majority of the contaminated soil identified in previous investigations was removed from the site.

The excavations were subsequently backfilled with 2,800 tons of amended soil that was then covered with 9,400 tons of clean fill. It was thought that the removal of the PCP contaminated soil and the use of soil amendments could also act to reduce PCP concentrations in groundwater over time.

The 2005 soil investigation showed that several areas of PCP contaminated soil remain at the site, both at the surface and at depth. PCP was detected in 30 of the 42 soil borings done at the site. The highest levels of PCP were found near the former process area, and PCP in four surface soil samples exceeded the MPCA commercial/industrial SRV.

The results of the investigation showed that a significant area of soil contamination, extending to below the water table was present at the site in at least two locations, and that groundwater at the site had been severely impacted by site contaminants.

Groundwater investigations and remediation

Since site investigation activities began, numerous monitoring wells have been installed on and off the site to evaluate groundwater conditions.

In 1995, PCP was detected at a concentration of 8,400 micrograms per litre ($\mu\text{g/L}$) at one well location with other locations showing very low levels.

In 1997, PCP was detected at a concentration of 3,900 $\mu\text{g/L}$ from one of the sites monitoring wells just south of the former process area;

The most recent groundwater monitoring event, conducted in 2005, detected PCP at a number of locations, the highest of which being 20,000 $\mu\text{g/L}$, was found at the same monitoring well just south of the former process area. PCP breakdown products were also detected in some wells, although at much lower concentrations.

High levels of PCP contamination have also been identified in the local St. Peter aquifer, with the extent of contamination being extensive with the highest level of PCP found to be 11,000 $\mu\text{g/L}$. High concentrations of PCP (in excess of 1,000 $\mu\text{g/L}$) have also been found in monitoring wells located over 1,000 feet south of the site at depths of approximately 160 feet below grade. The full extent of the groundwater contamination in the lower St. Peter has not been defined but extends at least 3,000 feet south of the site.

Lower levels of PCP have been detected in the underlying Prairie du Chien formation. The maximum level of PCP detected in the Prairie du Chien was 1,100 $\mu\text{g/L}$. The extent of PCP contamination in the Prairie du Chien is still being defined.

In 2004, PCP, along with other POPs, was detected at a concentration of 35 µg/L in a monitoring well not normally considered part of the Cedar Service Site monitoring network. However, it is not known whether this contamination originated from activities from this site or from other, unrelated activities.

As of March 2006, groundwater investigations were ongoing with remediation activities on the remaining contaminated soil at the site, and groundwater contamination both on and off-site being undertaken.

Additional case studies relating to PCP and dioxins and furan contamination

As indicated in section 2.3, the production of PCP means that PCP based products will contain a number of micro contaminants including the POPs dioxins and furans, which are of high concern. This document is chiefly intended to provide guidance on PCP, its salts and esters only. However further useful case studies which highlight the issues surrounding contamination of land and farm animals by dioxins and furans as a result of PCP include:

- (a) Karouna-Reniera et al. (2007) Serum profiles of PCDDs and PCDFs, in individuals near the Escambia Wood Treating Company Superfund site in Pensacola, FL Chemosphere 69, 1312–1319 <http://www.sciencedirect.com/science/article/pii/S004565350700639X>;
- (b) Dahlgren J1, Takhar H, Schechter A, Schmidt R, Horsak R, Paepke O, Warshaw R, Lee A, Anderson-Mahoney P. (2007) Residential and biological exposure assessment of chemicals from a wood treatment plant. Chemosphere. 2007 Apr;67(9):S279-85. Epub 2007 Jan 17;
- (c) Kopper Wood treatment Site <https://www3.epa.gov/region5/cleanup/rcra/koppers/>;
- (d) Baker et al. 2007 Completion of in-situ thermal remediation of PAHs, PCP and dioxins at a former wood treatment facility. IT3'07 Conference, May 14-18, 2007, Phoenix, AZ;
- (e) Fries GF, Feil VJ, Zaylskie RG, Bialek KM, Rice CP Treated wood in livestock facilities: relationships among residues of pentachlorophenol, dioxins, and furans in wood and beef. Environ Pollut. 2002;116(2):301-7;
- (f) Huwe JK1, Davison K, Feil VJ, Larsen G, Lorentzen M, Zaylskie R, Tiernan TO Levels of polychlorinated dibenzo-p-dioxins and dibenzofurans in cattle raised at agricultural research facilities across the USA and the influence of pentachlorophenol-treated wood. Food Addit Contam. 2004 Feb;21(2):182-94;
- (g) Piskorska-Pliszczynska J, Strucinski P2, Mikolajczyk S3, Maszewski S3, Rachubik J3, Pajurek M3, Pentachlorophenol from an old henhouse as a dioxin source in eggs and related human exposure. Environ Pollut. 2016 Jan;208(Pt B):404-12. doi: 10.1016/j.envpol.2015.10.007. Epub 2015 Nov 11.

3.5 Summary of potential emission sources

Table 4 below provides an overview of the potential key sources for PCP to environment. Care should be made when reviewing this table as potential key sources on a nation-by-nation basis will vary and some sources may not be relevant for a given nation.

Table 4: summary of key emission sources for PCP⁴

| Intentional production, trade and use | |
|--|---------------------------|
| Potential Source | Current or no longer used |
| Production of PCP / PCP treatments | Ongoing |
| Production of Na-PCP / Na-PCP treatments | Ongoing |
| Production of PCP-L / PCP-L treatments | No longer used |
| Timber treating (utility poles and cross-arms) | Ongoing |
| Timber treating (particle board – Na-PCP) | Ongoing |
| Use in distemper paints | Ongoing |
| Use in heavy textiles and fabrics (PCP-L) | No longer used |
| Use in Oil drilling practices | No longer used |
| Use in surface biocides for masonry | No longer used |

⁴ Under the Stockholm Convention PCP and its salts and esters were added to Annex A (elimination) with specific exemptions for utility poles and cross-arms. However, for those Parties that have made a declaration in accordance with paragraph 4 of Article 25 and have not yet ratified, accepted, approved or accessed the amendment, the obligations of Annex A with respect to PCP and its salts and esters do not apply. This means that it is also possible for other uses to be ongoing (at least in the short to medium term).

| Intentional production, trade and use | |
|---|-----------------|
| Use in water treatment for sugar and rice crops | No longer used |
| Use as a defoliant for protection of cotton crops | No longer used |
| Use in treatment of leather goods | No longer used |
| Use in treatment of paper goods | No longer used |
| Use as a preservative in some types of glue | No longer used |
| Use as a preservative in some oil-based paints | No longer used |
| Use as intermediate in production of pharmaceuticals | No longer used |
| Use as an intermediate in some dyes and colourants | No longer used |
| Other sources of environmental release | |
| Potential Source | Major or minor* |
| Releases from production of PCP / PCP treatments without proper abatement control | Major |
| Released from production of Na-PCP / Na-PCP treatments without proper abatement control | Major |
| Releases from timber treating (utility poles and cross-arms) without proper abatement control | Major |
| Releases from timber treating (particle board – Na-PCP) without proper abatement control | Major |
| Releases from In-use timber | Major |
| Releases from end of life timber consigned to landfill | Minor |
| Releases from combustion of treated timber | Minor |
| Releases from natural fires | Minor |

3.6 Inventory of PCP based on production, use, and waste cycle aspects

3.6.1 Introduction

This chapter provides a detailed overview for all potential emission sources using a life cycle approach. This covers the manufacture of PCP, treatment of wood with PCP based products, in-use emissions, and end of life management and potential emissions. It also includes comment on potential hot spots and need to identify and inventory these sites also. Some useful case studies regarding hotspots have also been provided as examples of the kind of issues that can be encountered. The information provided within this chapter is intended to give useful default values that can be used. However, best practice will be to make use of country centric data wherever possible. It is also important to recognise that practices may vary regionally as will climatic conditions and this may affect the rate of emission as well as the importance of specific emission vectors (e.g. air, land, water). A table of default emission factors based on the details in this chapter is provided within appendix 1.

It should also be noted that in the frame of the Stockholm Convention BAT/BEP expert process there is work to develop guidance on emission abatement and emission reduction. This guidance document is intended to aid the reader in the development of emission inventories to act as the evidence base for policy planning in targeting emission control and minimization. Please also refer to the guidance to be developed by the BAT/BEP experts for further details on emission abatement approaches.

3.6.2 Phase 1 – The intentional production and use of PCP

Manufacture of PCP

PCP can be produced by several methods, including the following (IEP, 2008; UNEP, 2013e):

- (a) Direct chlorination of phenols and hydrolysis of hexachlorobenzene. This is carried out in two steps. First, liquid phenol, chlorophenol, or a polychlorophenol is bubbled with chlorine gas at 30 - 40 °C to produce 2,4,6-trichlorophenol, which is then converted to PCP by further chlorination at progressively higher temperatures in the presence of various catalysts (aluminium, antimony, their chlorides, and others);
- (b) An alkaline hydrolysis of hexachlorobenzene (HCB) in methanol and dihydric alcohols, in water and mixtures of different solvents in an autoclave at 130 - 170 °C;

(c) Thermolysis of hexachlorocyclohexane (HCH), including a chlorination step and hydrolysis.

It is difficult to determine exact volumes of releases to the environment from sources of PCP, Na-PCP and PCP-L production. Emission factors for PCP and Na-PCP 'product' were reported by UNEP (2013e) as 634 µg TEQ/kg product and 12.5 µg TEQ/kg product respectively. Emission factors for air, water, land and residues were not reported in this study.

Air emissions rates (maximum values) of phenolic and non-phenolic compounds during PCP production were also reported by BUA (1986) [as cited in IEP, 2008]. The annual air emission value for PCP resulting from the production of approximately 2000 tonnes of PCP or Na-PCP were estimated to be 18 kg/year and 65 kg/year respectively.

While no waste water is expected to occur during the production of PCP, the annual loss of various compounds resulting from Na-PCP production into the waste water was estimated at 60 kg/year (BUA, 1986 [as cited in IEP, 2008]). The volume of contaminated wastewater generated during the production of Na-PCP is small, because manufacturers and regulatory agencies have emphasized efficient process design (IEP, 2008).

The production of approximately 2000 tonnes of PCP/year typically generates washing methanol, activated charcoal, and other wastes. These wastes, as well as the filtration sludge resulting from Na-PCP production, contain considerable amounts of hazardous chemicals (IEP, 2008). This includes the production of PCP at rates of 1350 kg/year and 900 kg/year (see Table 5).

Table 5: Phenolic and non-phenolic compounds in the combined wastes (PCP production) and filtration sludge (Na-PCP production). Source: IEP (2008)

| Compound | Combined wastes (kg/year) | Filtration sludge (kg/year) |
|--------------------------|---------------------------|-----------------------------|
| PCP | 1350 | 900 |
| Other chlorophenols | 0.7 | Ns |
| Hexachlorobenzene | ns | 6000 |
| Decachlorobiphenyl | ns | 3400 |
| Decachlorophenoxybenzene | ns | 44 |
| OCDD (OCDF) | 0.98 | 0.67 (0.67) |
| H7CDDs (H7CDFs) | 0.13 | 0.17 (0.045) |
| H6CDDs (H6CDFs) | 0.013 | 0.092 (0.015) |
| P5CDDs (P5CDFs) | 0.003 x 10 ⁻³ | 0.016 (0.005) |
| T4CDDs (T4CDFs) | 0.002 x 10 ⁻³ | 0.007 (0.001) |
| 2,3,7,8-T4CDD | ns | 0.001 |

Products, which are used in wood treatment or in textile impregnation, may be ready-for-use products or may need some dilution, dissolution or addition of other (active) substances. Formulation of the treatment fluid may take place by the importer or the producer or the end user of the substance.

Total annual PCP releases to municipal waste water treatment facilities were estimated to be 5,300 kg (USEPA, 1980 [as cited in IEP, 2008]). Most of the pentachlorophenol removed from effluent streams by waste water treatment processes is adsorbed to sludge solids. Sludges from wood preservation industries historically have been estimated to contain up to 14 000 kg of PCP per year.

No precise estimates can be made of the total world production of PCP and Na-PCP. It is now thought that only one production plant of PCP still exists, located in Mexico, with a formulation plant of PCP located in the USA. It is reported that the KMG plant in the USA formulated 7 257 tonnes of PCP (liquid concentrate) in 2009, marketed for wood preservation purposes in the USA, Canada, and Mexico (UNECE, 2010). Mexico reported production of 6 610 tonnes of PCP in 2009.

According to the manufacturer, discharges of PCP to water from production do not exceed 10 g/l in their trade effluent. The manufacturer also states that this level of discharge applies also to the companies processing the textile fabrics. The trade effluent from the production plant is discharged to sewer from where it goes to a sewage treatment plant, which treats both industrial and domestic sewage from a wide area (OSPAR, 2004).

Timber treatment

A comprehensive description of the wood treatment process has been provided by USEPA (2008c). A flow diagram, summarising the wood treatment process, and the points at which emissions occur in this process, is presented in Figure 1.

The wood treatment process typically consists of two stages of treatment with PCPs, after preparation and drying of the timber.

PCP is generally purchased as solid blocks, usually weighing 907 kg. The PCP blocks are dissolved by placing them in the treatment cylinder or into a mix tank and recirculating heated oil between the cylinder or mix tank and the bulk storage tanks to produce a concentrated solution. The concentrate is then diluted to working concentration (5–9%) (Environment Canada, 2013).

Based on the reported use of PCP and survey results for the use of diluent, approximately 2 kg of diluent oil per cubic foot of treated pole was used on average (Bollin and Smith, 2011). An average retention of 5.7 kg/m³ was calculated (Bollin and Smith, 2011).

The PCP preservative mixture is applied in a pressure cylinder, which is typically up to 45 m long x 2 m in diameter. Specific treatment parameters (e.g. temperature, pressure and duration) will vary depending on the specific purpose of application and will be dictated by the species of wood, the wood product and the initial moisture content of the wood (USEPA, 2008c).

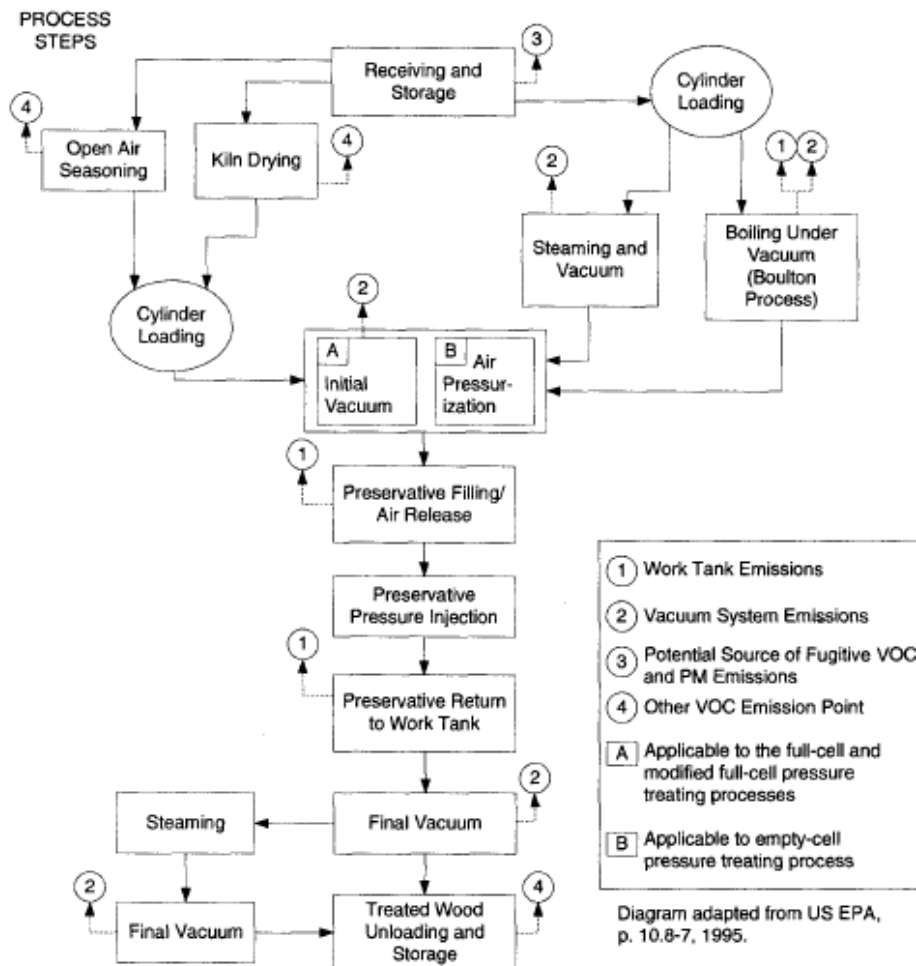


Figure 1: Flow diagram of the typical wood pressure treatment process (USEPA, 2008)

As detailed by Environment Canada (2013), the wood-preserving treatment process can consist of two processes, either:

- (a) A pressure treatment process – typically the ‘empty cell’ process, which can consist of either:
 - (i) The Rueping process – applies an initial air pressure (200–500 kPa for 15 minutes) to the wood charge in the cylinder prior to admitting the preservative. The pressure compresses

the air inside the wood. Hot preservative is then admitted to the wood without releasing the air pressure. The pressure is increased to a typical maximum of 1040 kPa and held until predetermined solution absorption has been achieved. When the pressure is released at the completion of the impregnation cycle, the compressed air in the wood expands and expels excess preservative. This effect, which is called the “kickback”, is usually enhanced by a quick final vacuum. Excess preservative is returned to storage for use in subsequent treatments;

- (ii) The Lowry process – similar to the Rueping process, except that no initial air is applied, and the preservative is admitted at atmospheric pressure. The remainder of the process continues in the same manner as the Rueping process. There is usually a smaller amount of preservative recovered by the kickback in a Lowry process;
- (iii) According to the AWWA, temperatures during the entire pressure period for treatment using oil-borne preservatives should not exceed 100°C (USEPA, 2008c).

(b) A thermal treatment process:

- (i) During the cycle, dry wood is first immersed in hot preservative (88 to 113°C) for a minimum of six hours (hot bath). Thereafter, the hot preservative is quickly replaced by cooler preservative for at least two hours (cold bath). A pressure vessel is not required to carry out the process;
- (ii) Treatment cycles are followed by a final vacuum, which equilibrates internal pressure, removes air and preservative from the surface fibres of wood and, in the case of oil-borne treatments that use elevated temperatures, cools the wood. The impregnation cycle may be followed by an expansion bath or a final steam cycle, both of which add a final vacuum step. The poles are left in the treatment tanks to cool and to allow any excess preservative to drip off;
- (iii) Typical preservative PCP retention in treated wood 3.4–16 kg/m³ of treated wood preservative (Environment Canada, 2013).

Storage

The treated wood is withdrawn from the treating cylinder and stored on a drip pad until dripping has stopped. From there the treated wood is removed from the drip pad and stored in a designated area until it is transported to the customer.

The PCP oil-borne treatment processes (both pressure and thermal) generate liquid and solid wastes and emissions to air. The points in the treatment cycle where emissions occur are shown in Figure 1. Here, these emission sources (for both pressure and thermal processes) are summarised briefly. It should be noted that measured emission data or data to estimate emissions are not available for many of these processes (IEP, 2008).

The TRI estimated the amounts of PCP discharged to the environment from manufacturing and processing facilities in the United States in 1999 (TRI99, 2001 [as cited in IEP, 2008]). These are shown in Table 6. It should be noted, the TRI data should be used with caution because only certain types of facilities are required to report (IEP, 2008).

According to a Finnish study at the beginning of the 1980s PCP-containing solid waste of about 0.3 litres per m³ treated wood was collected (Viitasaari, 1988 [as cited in IEP, 2008]).

Table 6: Estimated levels of PCP discharged to the environment from manufacturing and processing facilities in the USA in 1999. Source: TRI99, 2001 [as cited in IEP, 2008]

| Number of facilities | Reported amounts released in (kg/year) | | | | | |
|----------------------|--|-------|-------|----------------------|-----------------------|-------------------------------|
| | Air | Water | Land | Total onsite release | Total offsite release | Total on and off-site release |
| 47 | 592 | 579 | 44832 | 46006 | 7941 | 53947 |

For liquid wastes, leaks and drips of oil solutions are contained and reused in the treatment process. Liquids such as condensates, wash waters and infiltrating waters, which cannot be reused, require treatment to remove oil and PCP prior to discharge.

Liquid discharges from the pressure treatment process, include:

- (a) Condensates removed from the wood during conditioning and during the initial application of the vacuum process;
- (b) Water released by the wood during the treating cycle and subsequently separated from the unabsorbed treatment oil prior to recycling;
- (c) Wash waters.

Although no liquid process wastes are produced during thermal treatment, the following situations could create liquid releases:

- (a) Spills or overflows of liquid from open treatment tanks;
- (b) Infiltration of groundwater into tank containment systems;
- (c) Leaks from treatment tanks that have no containment provisions;
- (d) Surface runoff from the treated wood storage areas.
- (e) These liquids can contain PCP and should be treated before discharge as a waste stream.

Because PCP wood preservation facility sites are generally large, considerable volumes of storm runoff waters originate from these sites. Precautions are, therefore, required to avoid contamination of storm runoff water. The PCP content in runoff waters depends on many factors, including drip and vacuum time in the last step of the pressure process; viscosity of the wood preservative; wood species; moisture content of the wood prior to application of preservative (i.e. adequacy of conditioning step); specific treatment process (i.e. Rueping or Lowry); effectiveness of the post pressure-cycle processes applied (expansion bath, final steaming, final vacuum); and exposure to the weather.

Solid wastes from treatment facilities that use oil-borne PCP may include the following:

- (a) Sludges from treatment and storage tanks, sumps and pressure cylinders;
- (b) Sludges from wastewater treatment processes (e.g. flocculated material);
- (c) Containers or wrappings and pallets from bulk PCP;
- (d) Contaminated soils; and
- (e) Pallets and wrappings from bulk PCP.

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

- (a) Dust and vapours from manual unwrapping of PCP blocks;
- (b) Vapours from block storage;
- (c) Emissions during wood conditioning and the final vacuum step;
- (d) Vapours from tank vents;
- (e) Vapours from venting cylinders;
- (f) Vapours from the opening of cylinder doors;
- (g) Vapours from freshly treated charges; and
- (h) Vapours from vacuum system outlets.

In Canada PCP can only be used in specialised facilities compliant with appropriate technical guidance for the design and operation of wood preservation facilities (Environment Canada, 2004). This technical guidance aims to minimise potential adverse effects to the environment and/or human health, establishing Best Management Practices for PCP treated products (Environment Canada, 2004). This applies to both the design of facilities and the operating procedures for both pressure and thermal treatment processes.

Environment Canada (2013) provides a detailed description of best practice measures treatment plants should implement in order to prevent and/or reduce releases of PCP to the environment. These measures are summarised in Table 7.

Contaminated water solutions may be generated during this process, requiring oil and PCP to be removed from wastewaters prior to discharge. The techniques may include one or a combination of the following:

- (a) Gravity separation;
- (b) Oil/water API separation, plate separation;
- (c) Activated sludge treatment;
- (d) Activated carbon treatment;
- (e) Physical-chemical treatment (i.e. flocculation); and
- (f) Evaporation/condensation.

It is also recommended that surface runoff from storage areas should be monitored for chlorophenols and oil.

The most feasible disposal option for chlorophenol wastes appears to be high-temperature thermal destruction by an approved facility.

While awaiting disposal, the contaminated solids should be held in leak proof containers in a specially designed area that is curbed with a paved or concrete sealed surface. The area should be roofed to protect the wastes from precipitation. Any seepage or leachate generated at the site should be contained.

Table 7: Examples of disposal practices for PCP-contaminated wastes

| Waste category | Examples | Recommendations |
|-----------------------------------|--|--|
| Liquid PCP/oil solutions | Spilled PCP/oil concentrates PCP work solutions Drips from freshly treated timber Material skimmed from the oil separators | <ul style="list-style-type: none"> • Collect and reuse |
| Liquid PCP/water solutions | Condensates Wash waters Infiltrating waters | <ul style="list-style-type: none"> • Treatment to remove oil and PCP to regulatory limits • Dispose of treated waters as per regulatory requirements |
| Contaminated solid wastes | Debris and bottom sludge from storage tanks, sumps and pressure cylinders Soils contaminated by spills Clean-up absorbents Filter and cleaning vacuum processes Solid fine residues from PCP or PCP/oil storage areas Wrapping used for PCP blocks Scraps, cuttings and shavings from PCP-treated timber | <ul style="list-style-type: none"> • Drain and/or drum, store and dispose of in accordance with provincial regulatory requirements (high-temperature thermal destruction at authorised facilities appears to be the most feasible disposal option) |
| Miscellaneous solid wastes | Empty containers and wrapping rinsed with alkaline water | <ul style="list-style-type: none"> • Dispose of in authorised sanitary landfills (subject to approval by the provincial regulatory agency) • Recuperated by authorized facilities |
| Contaminated storm runoff | Storm runoff or contaminated liquid discharges containing PCP require consultation with regulatory agency | <ul style="list-style-type: none"> • Prevent or minimize contamination of storm runoff to greatest possible extent • Monitor surface water discharges (in consultation with the provincial regulatory agency) to assess contamination concentrations and determine need for control • Provide means for collection of contaminated storm runoff |
| Firefighting water runoff | As above for contaminated storm runoff | <ul style="list-style-type: none"> • Consider containment for where PCP or PCP/oil solutions are present • Consult with provincial regulatory agency to determine acceptable disposal practices |

Non-timber treatment uses of PCP

As discussed in Chapter 3.2, PCP has historically been used in a wide variety of non-timber applications.

Leather treatment

PCP was commonly used as a preservative in leather from the 1970s to protect leather goods from fungal damage during the wet processing of these materials. However its use for this purpose declined rapidly in many countries as its use became increasingly restricted due to human health and environmental concerns (Fontoura and Gutterres, 2015). PCP-L and Na-PCP have also been used in the treatment of leather (UNEP/POPS/POPRC.9/INF/7).

Historically, PCP has been used for leather preservation in, the USA, Mexico, India, Europe and Russia (UNEP/POPS/POPRC.9/INF/7). Data on the volumes of PCP used for this process are not available. PCP (and PCP-L and Na-PCP) has not been used for leather preservation in the USA since the 1990s (OSPAR, 2004) and the EU in 1993. As reported in OSPAR (2004), several studies have been conducted (between 1990 and 1993) on the PCP content of leather goods in Germany. 660 samples of leather products (shoes, gloves, insoles, etc.) were analysed in 11 German Federal States. The PCP content in 24% of leather goods exceeded the limit value of 5 mg/kg.

It is expected that PCP will have been released to the environment in waste water effluent from leather production facilities and from imported leather products (e.g. clothing, home furnishing and industrial applications) during their useful life or upon disposal. Moreover, imported goods can also be treated with PCP may not comply with national or international standards and therefore may not be accepted for this specific use in particular countries. Since it is not possible to estimate the volume or number of treated products produced in or imported into specific countries or regions, release estimates from these sources cannot be made (OSPAR, 2004).

Textile treatment

PCP, Na-PCP and PCP-L have been used to treat textiles which are subject to attack by fungi and bacteria during storage and use.

In the UK, PCP and Na-PCP has been used as an anti-mildew agent in the wool textile industry, as well as an antifungal agent in textiles other than wool (cotton, Flax and jute fabric, ropes, cordage and tentage) (IEP, 2008). The USA has also reported the use of PCP as a microbiocide for burlap, canvas, cotton, rope, and twine (IEP, 2008). PCP-L was developed especially for application on fabrics (IEP, 2008) and is used in the treatment of fabrics and webbing, and also of yarns and ropes, particularly those used in heavy-duty military applications. Industries such as leather tanning and textile factories may have released up to 2,000 kg and 5,500 kg of PCP, respectively, in their waste water discharges to surface waters on an annual basis in the 1970s (EPA, 1980 [as cited in IEP, 2008]).

Pentachlorophenyl laurate (PCP-L) is insoluble in water and so is applied either in solvent solution or, more commonly, as a concentrated aqueous solution/emulsion (IEP, 2008). Releases to waste water may occur where equipment is washed out between batching processes. During dyeing treatment 80% of the PCP-L in the emulsion is adsorbed to the fibre or yarn. When textile-finishing operations include a highly alkaline wash the pH of the wastewater is high and when wastewater- containing PCP-L is mixed with this water, PCP-L is likely to undergo chemical hydrolysis, producing PCP in its ionic form (IEP, 2008). Broad estimates of PCP-L releases to water are around 900 kg and PCP releases around 600 kg per year from the production of PCP-L (IEP, 2008).

Agriculture

PCP and Na-PCP have been used in a number of agricultural applications. This has included the large scale use of PCP in a number of geographic regions e.g. Australia (Camenzuli et al. 2015) China (Zheng et al. 2012), Japan (Masunaga et al. 2001, Yao et al. 2002), Suriname (National Implementation Plan Suriname, 2011). Examples of usage for these products include:

- (a) To prevent wood decay, in farm buildings, fences, and storage facilities;
- (b) As a herbicide and desiccant for forage seed crops, a herbicide for non-food vegetation control, a biocide in the post-harvest washing of fruit, and for general weed control;
- (c) As an insecticide for use in beehives, seed plots, and greenhouses;
- (d) As a herbicide in paddy and upland rice fields, particularly in Japan and also the USA.

For formulation of fungicidal and insecticidal solutions and for incorporation into other manufactured pesticide products.

Na-PCP production

PCP is also used to produce Na-PCP. Until 1984, Na-PCP was produced using the alkaline hydrolysis of hexachlorobenzene. Now, however, it is produced by dissolving PCP flakes in sodium hydroxide solution (Borysiewicz 2008). The industry association Indian Chemical Council (ICC) reports that Na-PCP is also used in India mainly as a wood preservative but also for the preservation of water-based 'distemper paints' while in storage (ICC, 2014). Na-PCP has also been used for control of the intermediate snail hosts of schistosomiasis (WHO, 1987).

Other application and uses

PCP and Na-PCP had been approved for a number of applications in the food industry, such as biocides in packaging materials and glues (IEP, 2008). PCP has also been used as preservative in oil-based paints and adhesives and as an intermediate product in the synthesis of pharmaceuticals as well as colouring substances. PCP has been used in slime control in pulp and paper production as well as waste water treatment. It is estimated that approximately 2000 kg of PCP, used as a biocide in cooling tower waters were discharged to surface waters in the USA in 1978 (USEPA, 1979 [as cited in IEP, 2008]). Other reported applications of PCP included health-care products and disinfectants for use in the home, farms, and hospitals. PCP might also be contained in dental-care products, bactericidal soaps, laundry products, and medical products for the skin (IEP, 2008).

There are very few data on the emission rates of PCP to the environment from the above applications and sources. PCP is no longer permitted for use in these applications in most countries, therefore, it is expected that release to the environment from these sources will no longer be significant. However, it is relevant to get estimates how much of PCP has been used in this area. In particular treated products (e.g. textiles, leather) have a long lifetime or if the application will lead to long lifetime for PCP in the environment.

3.6.3 Phase 2 – In use emissions from products treated with PCP

Releases from treated timber and equalisation

PCP is considered to be a relatively volatile compound. Based on its Henry's Law constant [1.94×10^{-3} atm·m³ / mole (25°C) (HENRYWIN v3.2 in U.S. EPA 2011 [as cited in UNEP, 2011a]), it has the potential to readily volatilize from surfaces (e.g. treated wood products, soils and water) (UNEP, 2013a). Volatilisation of PCP from treated wooden utility poles and other structures is, therefore, expected to be a significant route of loss for PCP during their service life. However, the extent and rate of PCP loss will vary depending on the age and type of the treated wooden products and different studies vary in their estimate of volatilisation rates for PCP.

For example, a typical loss rate of PCP from treated wood is estimated in the UK to be ~5% of the total amount of the preservative applied per year (Wild et al., 1992). However, during the first 12 months evaporation rates are shown to be much higher, with around 30% of PCP loss reported in some cases (UNECE, 2010) as freshly treated timber will contain PCP more readily available for volatilisation.

In the US, PCP has historically been estimated to volatilise from the surface of treated wood products at an estimated rate of 340,000 kg annually, or roughly 2% of the total amount of preservative applied (IEP, 2008). These estimates are representative of usage of the compound in those applications in the 1970s (USEPA, 1980 [as cited in IEP, 2008]).

A2 (Bollin and Smith 2011) report the results of a model, estimating that over its service life, a PCP-treated utility pole could release 60 per cent of its PCP (based on a 60-year service life). It was predicted that 1.8 percent could be released to the air and 57.2 percent released to the ground. This release model assumes 1.28×10^{-4} kg/m³ of PCP is released over the first 10 years followed by a release rate at 20 percent of the initial rate for the remainder of the pole life.

In the UK, Wild et al. (1992) consider that direct releases by spillages, volatilisation and PCP in wastewaters from the timber, textile and agricultural industries were by far the most important release sources, with volatilisation releasing the highest levels of PCP.

PCP can also be released through surface runoff, either from treated wood in situ during its service life, or during storage prior to use. Estimates of PCA release rates from surface run-off during service life are not available.

Estimates of PCP in the runoff from PCP-treated wood in stacks is estimated based on studies done by Morrell et al. (2009) [as cited in Bollin and Smith, 2011]) at approximately 2 ppm. Assuming the treated poles remain at the treatment yard for 1 month and average U.S. rainfall is approximately 33 inches (0.83m) of rain per year, Morrell et al. (2009) calculate a release factor of approximately 0.32 kg/m³ of PCP-treated poles produced. Similar releases are assumed for storage of PCP-treated poles in stacks at the utility staging areas, prior to placement in-service (Bollin and Smith, 2011).

As much as 228,000 kg of PCP, used in cooling tower waters as an anti-fouling agent, have been released to the atmosphere through volatilization with heated water and steam in the past [USEPA 1980 (as cited in IEP, 2008)]. However, pentachlorophenol is no longer commonly used for this purpose.

Rain may wash Na-PCP from the surface of the treated pallets, leading to high local levels in soils where pallets and pallet boards are stored and used in the open (Hobbs et al., 1993).

A study in the US (EPRI, 1995) reports on the analysis of soil samples from 31 wood pole sites, to investigate release and distribution of PCP from treated utility poles. The study noted similarity in PCP behaviour between sites; with a sharp decrease in concentration away from the pole (average of 1 order of magnitude difference between 3 and 8 inches from the pole). This could indicate that PCP concentrations are highest in close proximity to the poles, suggesting volatilisation and/or wash off of PCP from treated utility poles could be a source of soil contamination close to their point of use.

Na-PCP may also reach the environment by volatilisation in spite of its low volatility. In a doctoral thesis by Marchal (1996) [as cited in IEP, 2008] PCP emission rates from Na-PCP treated wood were measured. In this study, small pine wood blocks were treated by immersion in Na-PCP for 18 hours and then dried for 3 weeks. PCP emissions were measured in a flux chamber. An average steady-state flux rate of 10.8 $\mu\text{g}/\text{m}^2/\text{hour}$ was observed after 96 hours, based on a loading rate of 5.4 m^2/m^3 (wood surface/chamber volume). Marchal observed that PCP emissions were strongly affected by both temperature and the loading rate. Wood treated with Na-PCP showed lowest emissions to air ranging from 33 to 46 $\mu\text{g}/\text{m}^3$.

An estimate of PCP emissions to air from Na-PCP treated wood can be derived from a doctoral thesis by Marchal (1996). Based on the flux rate from the Marchal thesis, emissions to air in Portugal are: 516 kg/year, in France 344 kg/year, in the UK 229 kg/year and in Spain 115 kg/year. Depending on the solvent, temperature, pH, and type of wood 30 – 80 % of PCP may evaporate within 12 months from dip- or brush treated wood (WHO 1987).

Replacement rates for timber

In the USA the Utility Solid Waste Activities Group (USWAG) members represent more than 85 percent of the total electric generating capacity of the United States, and service more than 95 percent of the nation's consumers of electricity (IEP, 2008). A 2002 USWAG Survey revealed that approximately 44 million treated wood poles currently are in service by those USWAG members. When extrapolated out to reflect the entire electric power and telecommunication industries, USWAG estimates that there are approximately 130 to 135 million treated wood poles currently in service in the USA (IEP, 2008).

Respondents to the USWAG Survey reported that they purchased approximately 719,000 new treated wood poles annually, either to provide electrical service to new service areas or to replace damaged poles in existing service areas. When extrapolated out, one can estimate that at least several million treated wood poles are purchased annually in the U.S. by electric utilities alone (IEP, 2008).

Vlosky (2009) reported, based on a survey of wood preserving operations provided by the Southern Forest Products Association (SFPA) in the USA, that an estimated 651,000 m^3 of utility-distribution poles, 337,000 m^3 of utility-transmission poles, and 65,000 m^3 of fence posts (round) were treated with oil-borne preservatives in 2007. In addition, an estimated 23,000 m^3 of dimension lumber is estimated to have been treated in 2007. Totalled together, these applications therefore used approximately 991,000 m^3 of utility poles in 2007. In 2004, PCP represented 93% of total volume of oil borne preservatives used (Vlosky, 2009) Respondents in this study reported using 9.7 million kg of PCP active ingredients in 2007.

For 2007, Douglas-fir accounted for 60% of lumber treated with oil borne preservatives followed by Southern pine (26%). Southern pine accounts for 70% of treated Roundwood followed by Douglas-fir (29%).

The length of time that a treated wood pole remains in a utility line is dependent upon a number of factors. Often, poles are removed from service before the end of their useful service life, such as for road widening (Bollin and Smith, 2011). It is expected pole service lives will be between 30 and 59 years, but replacement rates indicate longer average lives of between 60 and 80 years (based on survey of one US utility company).

Christodoulou et al. (2009) provided a statistical analysis, for the evaluation of the life expectancy and the production of a survival curve of a typical Hellenic distribution wooden poles in-service. Modelling these results derived a life expectancy of 45-47 years.

Pope (2004 [as cited in (Bollin and Smith, 2011)]) uses pole inspection data of over 750,000 poles showing that poles with no maintenance had an average service life (50 percent rejected as needing replacement) of 40–50 years, but with normal inspection and maintenance (the current practice), the average service life could extend to 60 or more

years. Thus, assuming current inspection practices will continue, the average service life of 60 years is typically quoted (Bollin and Smith, 2011).

Replacement of wooden utility poles can result due to a number of factors, including failure caused by weather (e.g. strong wind/lightning); corrosion and/or decay; defective materials; road re-routing or widening etc.

SCS (2013) conducted a survey of 260 utilities in the USA (sample representing ~25% of all poles in service) and estimated the average service lifetime for each material type; this average lifetime was used to calculate annual average failure rates, determining the number of poles requiring replacement. It was estimated that an average wood pole service life of 30-40 years, corresponding to an annual failure and replacement rate of around 2.5%.

Identification of treated timber

Most utility poles, during the manufacturing process, are typically marked in accordance with the requirements found in ANSI O5.1 or CSA O15-15. The typical information contained on the marking includes a supplier trademark or code, the year of treatment, a code for the plant location, the species of wood, the preservative type and the class and length of the pole. Additional information may be included based on a utility's specifications.

The information is either burn-branded on the pole or embossed on a recessed metal tag affixed to the pole. The tag is normally located at 10 feet from the butt on poles shorter than 55 feet, and at 14 feet from the butt on poles 55 feet and longer. Given the typical setting depths of poles, this normally places the information in the zone from 2 to 6 feet from the ground on an installed pole.

3.6.4 Phase 3 – Management of end of life products treated with PCP

PCP, its salts and esters are listed in Annex A to the Stockholm Convention, meaning Parties to the Convention should prohibit and/or take the legal and administrative measures necessary to eliminate production and use. Parties to the Convention listed in the register of specific exemptions are permitted to produce and use PCP for utility poles and cross-arms, in accordance with the specific provisions. However, treated wood has a finite life-span and, at the end of its useful life, should be disposed of.

Additionally, there may be a number of historic uses, particularly leather and suede, where there are significant existing stockpiles that need to be managed suitably. Details on the scale of these stockpiles are unclear and therefore it is difficult to provide further information. Section 4.2 of this guidance document provides further details on non-timber uses of PCP, its salts and esters. It should be assumed that where such stockpiles exist, intervention is needed to manage the suitable end of life disposal and potential release to environment.

Please refer to the technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with pentachlorophenol and its salts and esters⁵ (UNEP/CHW.13/6/Add.3/Rev.1) for further information.

Identification of treated timber within the waste stream

In general, wood used in a commercial/industrial setting will be treated by some means to prevent degradation and to increase its service life. Typically, wood will be treated with one of three product types; PCP, Creosote or chromated copper arsenate (CCA).

As stated in Section 4.2, such wood should be appropriately labelled to allow quick identification of the treatment product. However, if not appropriately labelled the treatment product can be established through suitable sampling and analysis.

Additionally, where appropriate labelling is absent, and in absence of, or prior to undertaking sampling and analysis, the treatment product used can sometimes be inferred through visual inspection (noting that this is an indicative method and should not be used to replace labelling and/or sampling and analysis):

- (a) CCA – the surface of the wood will often appear to have a slight blue/green tint to it due to oxidation of the copper in the CCA;
- (b) Creosote – This is a tar like substance which often gives the surface of the wood a black/dark brown tar like (often sticky) finish; and
- (c) PCP – PCP itself is not noticeable leaving the surface of the wood apparently unchanged to its natural appearance. Thus if the wood does not appear to show signs of CCA or creosote, it is likely to have been treated with PCP.

⁵ <http://www.basel.int/Implementation/Publications/LatestTechnicalGuidelines/tabid/5875/Default.aspx>.

Examples of CCA, creosote and PCP treated timbers are shown in Figure 2, Figure 3 and Figure 4 respectively.



Figure 2: Timber treated with CCA (Reference NPIC, 2015)



Figure 3: Timber treated with creosote (Reference Bayou Forest Products, 2017)



Figure 4: Timber treated with PCP (Reference Environment Canada, 2017)

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- | | | |
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Appendix 1: Tables of default data to help inventory development

| Source | Vector/Receptor | Emission factor | Comments/Details | Reference |
|--|---|---|--|----------------------------------|
| PCP Production | Air | 18 kg/year | Based on production of approximately 2000 tonnes of PCP | IEP(2008) |
| Na-PCP Production | Air | 65 kg/year | Based on production of approximately 2000 tonnes of Na-PCP | IEP(2008) |
| PCP Production | Residue (Combined wastes) | 1350 kg/year | USA Facilities | IEP(2008) |
| Na-PCP Production | Residue (Filtration sludge) | 900 kg/year | USA Facilities | IEP(2008) |
| Manufacturing and processing facilities | Air | 592 kg/year | USA Facilities | IEP(2008) |
| Manufacturing and processing facilities | Water | 579 kg/year | USA Facilities | IEP(2008) |
| Manufacturing and processing facilities | Land | 44832 kg/year | USA Facilities | IEP(2008) |
| Volatilisation from PCP-treated utility poles | Air | 30% loss in first year of use ; 2-5% subsequent loss from pole per year | based on UK and US data from the 1970s -1990s | Wild et al. (1992); IEP, 2008 |
| Volatilisation from PCP-treated utility poles | Air | 1.28 x10 ⁻⁴ kg/m ³ of PCP is released over the first 10 years followed by a release rate at 20 percent of the initial rate for the remainder of the pole life | 1.8 percent released to the air | Bollin and Smith (2011) |
| | Land | 1.28 x10 ⁻⁴ kg/m ³ of PCP is released over the first 10 years followed by a release rate at 20 percent of the initial rate for the remainder of the pole life | 57.2 percent released to the ground | Bollin and Smith (2011) |
| PCP in the runoff from PCP-treated wood in stacks | Land/water | 0.32 kg/m ³ of PCP-treated poles | Assuming the treated poles remain at the treatment yard for 1 month and average U.S. rainfall is approximately 33 inches (0.83m) of rain per year, | Morrell et al. (2009) |
| Na-PCP volatilisation from treated wood | Air | 10.8 µg/m ² /hour | After 96 hours, based on a loading rate of 5.4 m ² /m ³ (wood surface/chamber volume) | Marchal (1996). |
| PCP concentrations within mixed waste wood | Residue (mixed waste wood for processing) | <0.05 mg / kg | Raw wood with no obvious signs of treatment. | Pohlandt et al (1995) |
| | | 0.25 mg/kg | Mixed treated waste wood where PCP is suspected to having been used | |

Appendix 2: Suggested outline for a questionnaire to gather information

| A | | Information about the organisation and the site | |
|----|--|--|--|
| 1 | Name: | | |
| 2 | Address: | | |
| 3 | Address of site: (if different from A2) | | |
| 4 | Phone: | | |
| | Fax: | | |
| | E-mail: | | |
| 5 | Name/position of contact: | | |
| 6 | Type of organisation (PCP manufacturer company using PCP / regulatory agency / NGO / academic: | | |
| 7 | Public or private company? | | |
| 8 | Location: | Industrial zone | |
| | | Other urban area | |
| | | Rural area | |
| 9 | Number of staff at visited site: | >50 | |
| | | 10-50 | |
| | | <10 | |
| 10 | Do you manufacture or import PCP? | If manufacture, what annual tonnages are produced? | |
| | | If imported, what annual tonnages are imported? | |
| 11 | If you manufacture PCP do you have details of abatement systems used as part of an environmental permit? (if yes, please append permit to this questionnaire) | | |

| B | | Information related to the potential PCP uses and emissions | |
|--|---|---|--|
| Questions for individual operators | | | |
| 1 | Do you make use of PCP for timber treatment activities? If yes please answer Q 2 - 8 | | |
| 2 | How much timber per annum is treated with PCP as tonnes? | | |
| 3 | What is the working concentration of PCP in the timber produced at your facility (mg/ft ²) | | |
| 4 | How much PCP contaminated waste is produced per annum at your facility? | | |
| 5 | How is waste managed? (i.e. what is the means of final disposal) | | |
| 6 | Does your facility use other pesticides for timber treatment as well as PCP? If so which? | | |
| 7 | Does your facility carry out any routine monitoring for PCP emissions? If so please answer Q 8. | | |
| 8 | Emission monitoring data as emission rates / annual totals | Emissions to air (g/m ²) | |
| | | Emissions to water (g/l) | |
| | | Emissions to waste (kg/tonne) | |
| | | Annual emissions to air kg | |
| | | Annual emissions to water kg | |
| | Annual quantities of PCP in waste as kg | | |
| 9 | Do you make use of PCP for uses other than timber treatment, please specify which | | |
| Questions for trade associations / regulators | | | |
| 10 | Do you have any data on annual production rates for timber treated with PCP (tonnes of timber) | | |

| | | |
|----|--|--|
| 11 | Do you have any data on annual quantities of imported timber treated with PCP (tonnes of timber) | |
| 12 | Do you have any data on the replacement rates for timber used in infrastructure networks | Type of network (e.g. power/telecoms/rail) Replacement rates as % of total in use |
| 13 | Average of utility poles / cross-arms within the infrastructure network | |

| C | | Information on wastes liable to contain PCP | |
|---|---|---|--|
| Questions for waste facility operators | | | |
| 1 | Please specify the nature of your facility (recycling, incinerator, landfill, waste handling, other) | | |
| 2 | Does your facility accept waste known to be contaminated by PCP (either production wastes or treated end of life timber) and how is treated? | | |
| 3 | What quantity of waste is managed by your facility? | | |
| 4 | Does your facility have any specific environmental permits relating to the management of hazardous waste? (if yes please append permit to this questionnaire) | | |
| 5 | Does your facility conduct routine monitoring for releases? If yes please answer question 6. | | |
| 6 | Please provide details of monitoring data as release rates of annual totals | Emissions to air (g/m ²) | |
| | | Emissions to ground water (g/l) | |
| | | Annual emissions to air kg | |
| | | Annual emissions to ground water kg | |
| | | Environmental monitoring for the site as soil concentrations (g/kg) | |
| Questions for regulators | | | |
| 7 | Please provide details of sites / facilities known to be managing PCP waste (append to this questionnaire as a separate document) | | |
| 8 | Do you have any details on enforcement actions brought for environmental release – either at sites of use, or from waste handling locations? | | |
| 9 | Has the regulator carried out any monitoring to corroborate environmental performance? If yes please answer Q10. | | |
| 10 | Please provide details of monitoring programmes undertaken as part of compliance checking (please append details separately to this questionnaire) | | |

| | | |
|----------|---|--|
| D | Information on potential contaminated sites (Questions for trade associations / regulating agencies) | |
| 1 | Do you have any details on former sites of manufacture for PCP? | |
| 2 | Do you have any details on former sites conducting timber treatment that may have used PCP in the past? | |
| 3 | Are you aware of any monitoring or initial research conducted to sample and analyse soils from former sites of manufacture and/or use? | |
| 4 | Do you have any contact details for representatives that may have further information on this topic? <i>(Please note that we will contact representatives detailed here. Please check that those named are happy to be contacted).</i> | |
| E | Information on Historic uses (Questions for trade associations / regulating agencies) | |
| 1 | Are you aware of any details surrounding the use of PCP for treatment in leather, textiles, paper and pulp or agriculture? <i>(Please list which industry sectors).</i> | |
| 2 | Can you please provide details of locations for facilities / former facilities that were known to be using PCP? <i>(Please indicate which industry sector each facility relates to).</i> | |
| 3 | Are any environmental monitoring data available for the sites identified in question 2 above? | |
| 4 | Are any environmental monitoring programmes planned for the sites identified in question 2 above? | |
| 5 | Have any monitoring programmes been used for sampling and analysis of leather, suede or textiles being imported into the country for presence of PCP? If yes, please provide details. <i>Question for regulators only.</i> | |
| 6 | Have any stockpiles of leather, suede or textile goods contaminated with PCP been identified within your nation? If yes, is data available on quantities and mechanism for final disposal? <i>Question for regulators only.</i> | |

Appendix 3: Named active substances for wood treatment within the EU

| Named active substance | CAS number | EU use restrictions |
|--|---|--|
| 4,5-Dichloro- 2-octyl-2H-isothiazol-3- one (DCOIT) | 64359-81-5 | Directive 2011/66/EU of 1 July 2011 |
| Alkyl (C12-16) dimethylbenzyl ammonium chloride - C12-16 ADBAC | 68424-85-1 | Directive 2013/7/EU of 21 February 2013 |
| Basic copper carbonate | 12069-69-1 | Directive 2012/2/EU of 9 February 2012 |
| Boric acid | 10043-35-3 | Directive 2009/94/EC of 31 July 2009 |
| Boric oxide | 1303-86-2 | Directive 2009/98/EC of 4 August 2009 |
| Bifenthrin | 82657-04-3 | Directive 2011/10/EU of 8 February 2011 |
| Chlorfenapyr | 122453-73-0 | Directive 2013/27/EU of 17 May 2013 |
| Clothianidin | 210880-92-5 | Directive 2008/15/EC of 15 February 2008 |
| Copper (II) oxide/ Copper hydroxide | 1317-38-0/ 20427-59-2 | Directive 2012/2/EU of 9 February 2012 |
| Creosote | 8001-58-9 | Directive 2011/71/EU of 26 July 2011 Authorisation will only be granted if deemed that no viable appropriate alternative is available. Those Authorities allowing such products in their territory shall report no later than 31 July 2016 to the Commission justifying their conclusion that there are no appropriate alternatives and indicating how the development of alternatives is promoted. |
| Cypermethrin | 52315-07-8 | Regulation (EU) No 945/2013 of 2 October 2013 |
| Dazomet | 533-74-4 | Directive 2010/50/EU of 10 August 2010 The EU level risk assessment addresses only professional use outdoors for the remedial treatment of wooden poles, such as transmission poles, by insertion of granules. If applicants at Member State level wish to seek authorisation for uses not covered at the EU level the authority should assess these uses with concern to protect risks to human populations and the environment. |
| Dichlofuanid | 1085-98-9 | Directive 2007/20/EC of 3 April 2007 |
| DDACarbonate | 894406-76-9 | Directive 2012/22/EU of 22 August 2012 |
| Didecyldimethylammonium Chloride (DDAC) | 7173-51-5 | Directive 2013/4/EU of 14 February 2013 |
| Disodium octaborate tetrahydrate | 12280-03-4 | Directive 2009/96/EC of 31 July 2009 |
| Disodium tetraborate (all species) | 12267-73-1/ 1303-96-4/ 1330-43-4/ | Directive 2009/91/EC of 31 July 2009 |
| Etofenprox | 80844-07-1 | Directive 2008/16/EC of 15 February 2008 |
| Fenoxycarb | 72490-01-8 | Directive 2011/12/EU of 8 February 2011 |
| Fenpropimorph | 67564-91-4 | Directive 2009/86/EC of 29 July 2009 |
| Flufenoxuron | 101463-69-8 | Directive 2012/20/EU of 6 July 2012 |
| Hydrogen cyanide | 74-90-8 | Directive 2012/42/EU of 26 November 2012 |
| IPBC | 55406-53-6 | Directive 2008/79/EC of 28 July 2008 |
| K-HDO | 66603-10-9 | Directive 2008/80/EC of 28 July 2008 |
| Propiconazole | 60207-90-1 | Directive 2008/78/EC of 25 July 2008 |
| Sulfuryl fluoride | 2699-79-8 | Directive 2006/140/EC of 20 December 2006 |
| Tebuconazole | 107534-96-3 | Directive 2008/86/EC of 5 September 2008 Under the EU regulation for placing biocidal products on the market (EC 528/2012); Tebuconazole has been identified as a candidate who meets Persistent, Bioaccumulative and Toxic (PBT) criteria. Considered a candidate for substitution with phase out of active use. |
| Thiabendazole | 148-79-8 | Directive 2008/85/EC of 5 September 2008 |
| Thiacloprid | 111988-49-9 | Directive 2009/88/EC of 30 July 2009 |
| Thiamethoxam | 153719-23-4 | Directive 2008/77/EC of 25 July 2008 |
| Tolyfluanid | 731-27-1 | Directive 2009/151/EC of 27 November 2009 |

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