LEARNING COURSE

Alternatives to POPs
Annex A

Pentachlorophenol (PCP)

GGKP, 2024

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Index

1. Annex A
2. Status of PCP under the Stockholm Convention
3. Pentachlorophenol (PCP) and its salts and esters
4. PCP production
5. PCP uses (as per Annex A)
6. PCP uses
7. Sources of environmental releases for PCP
8. PCP in stockpiles, products and waste
9. Sites potentially contaminated by PCP
10. Alternatives to PCP: policy planning for emission control and phase-out of PCP used for utility poles and cross-arms
    a) Step 1: Identification of issues at the national level
    b) Step 2: Engagement with industry/regulatory agencies/NGOs
    c) Step 3: Review and development of control options
    d) Step 4: Development of control plans
    e) Step 5: Awareness campaigns
    f) Step 6: Monitoring/compliance/feedback
    g) Step 7: International activities
11. Chemical alternatives to PCP
12. Non-chemical alternatives to PCP
13. Final remarks

POPs listed in Annex A

Parties must take measures to eliminate the production and use of the chemicals listed under Annex A.

Specific exemptions for use or production are listed in the Annex and apply only to Parties that register for them.

Status of PCP under the Stockholm Convention

- Pentachlorophenol (PCP) and its salts and esters are listed in Annex A with specific exemptions for use in utility poles and cross-arms (deicison SC-7/3).

- The Conference of the Parties also decided to insert note (vi) to reflect that pentachlorophenol, sodium pentachlorophenate, pentachlorophenyl laurate and pentachloroanisole are identified as POPs.

REF: Stockholm Convention - UNEP/POPS/COP.8/INF/20

Pentachlorophenol (PCP) and its salts and esters

- Pentachlorophenol is an organochlorine compound and was first introduced for use as a wood preservative in the 1930s.
- Polychlorinated dibenzo dioxins and furans (PCDD / PCDF) 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.
- 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 minimize and ultimately eliminate their release.

REF: UNEP/POPS/POPRC.10/10/Add.1 - UNEP/POPS/COP.8/INF/20

PCP production

- 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).
- Na-PCP and PCP-L in turn are produced using PCP as a starting material.
- PCP and its salt and esters are currently produced only in Mexico and in India, with formulation also taking place in the USA.
- 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.

PCP uses (as per Annex A)

Specific exemptions

- Pentachlorophenol for utility poles and cross-arms in accordance with the provisions of Part VIII of Annex A.
- Part VIII:
  - Each Party that has registered for the exemption, pursuant to Article 4 for the production and use of pentachlorophenol for utility poles and cross-arms shall take the necessary measures to ensure that utility poles and cross-arms containing pentachlorophenol can be easily identified by labelling or other means throughout their life cycles. Articles treated with pentachlorophenol should not be reused for purposes other than those exempted.

REF: Stockholm Convention

PCP uses

- PCP is a general biocide and has been used extensively as a fungicide, bactericide, herbicide, molluscicide, algaecide, insecticide, disinfectant, defoliant, anti-sapstain agent and anti-microbial agent in various industries including agriculture, textiles, paints, oil drilling and forestry.
- The major worldwide use of PCP has been as a heavy-duty wood preservative.
- PCP has also been used for the production of pentachlorophenyl laurate (PCP-L), which 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.
- Sodium pentachlorophenate (Na-PCP) was also used as a pesticide, namely as a molluscicide, for similar purposes as PCP in industrial wood preservation.

REF: UNEP/POPS/COP.8/INF/20 (Revised 2019) - UNEP/POPS/COP.8/INF/20

Sources of environmental releases for PCP

- PCP can be released to the environment during the course of its production, use and/or disposal via several release sources:
  - PCP treatment facilities;
  - Evaporation during in-service life of PCP-treated products and stockpiles;
  - Waste handling processes where PCP-treated products are sent to landfill or incinerated;
  - Contaminated sites resulting from historical use/production of PCP;
  - Improper practices (e.g. spills from industrial holding ponds from wood treatment facilities);
  - Re-volatilization from adsorbed residues; and
  - Domestic or forest fires.
- PCP can be formed unintentionally as a transformation product (metabolite) of other organochlorines such as hexachlorobenzene (HCB), quintozene (PCNB) and lindane.
- Pentachloroanisole (PCA) is a metabolite that might be formed through the methylation of PCP by soil or sediment microorganisms.

PCP in stockpiles, products and waste

- Based on a review of the major uses of PCP-based products the likely major stockpiles will be dominated by:
  - Treated wood and what type of wood (timber in constructions, utility poles, railway sleepers, etc.)
  - Treated leather
  - Treated textiles (but shorter lifetime)
- Alongside the issue of stockpiles, many sites exist that will be contaminated from the historical use of PCP and improper practices.
- PCP-treated wood contains substantial quantities of the compound. 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.

REF: UNEP/POPS/COP.8/INF/20 - UNEP/POPS/COP.8/INF/20 (Revised 2019)

Sites potentially contaminated by PCP

- Soil contamination can be an issue at wood preservation facilities if no effective measures are in place. In these areas, concentrations may stay high for a long time because of slow degradation in the soil.
- Contaminated sites such as former PCP production plants, and wood preservation plants may continue to be major sources of PCP to the environment.
- 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.

Alternatives to PCP: policy planning for emission control and phase-out of PCP used for utility poles and cross-arms

Planned approach for management of PCP

- To manage PCP at the national level, nit is necessary to understand what are the issues relevant to a given country, what control measures are needed, what form of stakeholder engagement is needed, and what activities should be undertaken to help minimize releases to the environment.

REF: UNEP/POPS/COP.8/INF/20

Alternatives to PCP: policy planning for emission control and phase-out of PCP used for utility poles and cross-arms

Step 1: Identification of issues at the national level

- To better understand the key important issues is essential for planning management of PCP.
- The development of emission inventories provides a valuable tool to help provide an evidence base for what the key issues are likely to be.
- The completion of this first stage should help the policymaker fully understand what the main issues are and where further control and work are needed.

REF: UNEP/POPS/COP.8/INF/20

Alternatives to PCP: policy planning for emission control and phase-out of PCP used for utility poles and cross-arms

Step 2: Engagement with industry/regulatory agencies/NGOs

- The contact with relevant stakeholders in this case could be used to help serve the following purposes:
    - Establish working groups between regulatory officials and industry representatives to help understand the key obstacles to phase-out of PCP for safer alternatives.
    - Help identify and manage key priorities for existing use.
    - Establish key contacts for government departments and regulatory agencies.
    - Contact with a wider audience such as NGOs and the public can be used to help gather feedback on what others perceive as being the priority issues for management.
- The completion of this second step is intended to inform the key issues, and technical/socio-economic obstacles that may be presented in managing the control and phase-out of PCP.

Alternatives to PCP: policy planning for emission control and phase-out of PCP used for utility poles and cross-arms

Step 3: Review and development of control options

- Intended to develop possible control options to manage the existing use of PCP and to aid the phase-out of PCP for safer alternatives.
- As part of the development of control options it will be necessary to undertake a feasibility assessment or cost-benefit study to help identify which options are likely to provide the best benefit against cost.

Alternatives to PCP: policy planning for emission control and phase-out of PCP used for utility poles and cross-arms

Step 3: Review and development of control options

- Possible policy control options:
  - Restrictions placed upon industry to prevent the reuse of treated timber for other applications (e.g. domestic) beyond the original use.
  - National authorities should coordinate with regional authorities to ensure that appropriate disposal procedures are adhered to and that PCP-containing wastes are identified.
  - The Stockholm Convention details time-limited exemptions for the continued use of PCP in utility poles and cross-arms. Working with industry groups it could be possible to set phase-out dates after which the use of PCP is prohibited.

Alternatives to PCP: policy planning for emission control and phase-out of PCP used for utility poles and cross-arms

Step 3: Review and development of control options

- Possible policy control options:
  - Policy options aimed to support innovation and development of alternatives to PCP:
    - Financial incentives for the development of commercially ready alternatives to PCP, which are demonstrated to be safer;
    - Establishment of innovation networks to help industry support one another with management and development of PCP alternatives for specific applications; and
    - Establishment of communication channels to provide information on innovation and case studies of how technological advances have been made.

Alternatives to PCP: policy planning for emission control and phase-out of PCP used for utility poles and cross-arms

Step 3: Review and development of control options

- Possible technical control options:
  - The labelling or branding of new PCP-treated wood would help to facilitate proper environmentally sound management of stockpiles and wastes.
  - BAT/BEP guidelines and provisions of Annex C to the Stockholm Convention provide information on the appropriate elimination or disposal technologies to be used for pressure-treated wood.
  - Identification of key restriction measures to limit the release of PCP from treated timber and potential exposure to both workers and the environment.
  - Additional training for enforcement agencies, particularly within the waste sector to help identify and manage treated wood more easily.

Alternatives to PCP: policy planning for emission control and phase-out of PCP used for utility poles and cross-arms

Step 4: Development of control plans

- The aim is to develop a plan of integrated options based on the list of all available options for control, minimization and transition to alternatives (Step 3),which should work together to help manage, control and minimize emissions and facilitate the transition of PCP for safer alternatives.
- It will also be necessary to set achievable targets over an appropriate timescale and to put in place mechanisms to assess how successful each option has been.

Alternatives to PCP: policy planning for emission control and phase-out of PCP used for utility poles and cross-arms

Step 5: Awareness campaigns

- Raising awareness of the key issues surrounding PCP and the need for control will help ensure that the control options utilized are as effective as possible and that all key stakeholders remain engaged with the process.
- Ensuring a high level of communication with industry will be of importance.
- Awareness campaigns should be tailored to best meet the needs of the target groups receiving the information.

REF: UNEP/POPS/COP.8/INF/20

Alternatives to PCP: policy planning for emission control and phase-out of PCP used for utility poles and cross-arms

Step 6: Monitoring/compliance/feedback

- The use of stakeholder engagement in Step 2, such as industry working groups and communication with enforcement agencies, could be used to provide information on compliance and feedback on how successful the options within the control plan have been.
- The use of environmental monitoring programmes to assess ambient concentrations of PCP in the natural environment will also be important to help track progress against the objective of reducing emissions to the natural environment, as well as ensuring the correct issues are being targeted.
- The outputs from monitoring, compliance work and feedback from stakeholders, can be used to help further tailor the understanding of key issues, and the work carried out in the preceding steps, to further develop planning.

Alternatives to PCP: policy planning for emission control and phase-out of PCP used for utility poles and cross-arms

Step 7: International activities

- Where PCP poses international issues, it is also important to give consideration to some international activities which can be used to help control the movement of PCP and PCP treated timber.
- PCP is listed under Annex III of the Rotterdam Convention, meaning that prior informed consent is required before PCP can be transported across politically boundaries as a commercial good.
- Chlorophenols are also listed under Annex I of the Basel Convention, meaning that waste contaminated with PCP also requires prior informed consent before crossing political borders for final destruction.

REF: UNEP/POPS/COP.8/INF/20

Chemical alternatives to PCP

- The US EPA (2008) and Environment Canada (2004) have identified the following key substances that are mass produced as wood preservatives (in addition to PCP):
  - Chromated copper arsenate (CCA)
  - Creosote-based products
  - Ammonical Copper Zinc Arsenate (ACZA)
  - Additional preservatives, including Ammonium Copper Quaternary (ACQ), Copper Naphthenate, copper azoles and azoles/permethrin

REF: UNEP/POPS/COP.8/INF/20 - UNEP/POPS/POPRC.10/10/Add.1

Chemical alternatives to PCP: **chromated copper arsenate (CCA)**

- Widely used in North America; recognized as the main preservative wood treatment product in the US for industrial use.
- CCA was voluntarily removed from use on wood intended for the domestic/residential use market in 2003 in both the US and Canada due to public health concerns about the leaching of arsenic.
- The EU approval for CCA ceased in September 2006. Wood already on the market treated with CCA can still be sold and used for permitted uses (not inside buildings for example).

Chemical alternatives to PCP: **chromated copper arsenate (CCA)**

Advantages

- CCA is recognized as producing a clean, dry, odour-free finish which is easy to paint, making CCA-treated wood more applicable to public locations.
- The high fixation rates for CCA also mean it is suitable for use in areas with high moisture soil content or high water table.

REF: UNEP/POPS/COP.8/INF/20 - UNEP/POPS/POPRC.10/10/Add.1

Chemical alternatives to PCP: **chromated copper arsenate (CCA)**

Disadvantages

- CCA treatments can have an effect on moisture content of wood leaving them particularly dry. For hot dry climates the use of CCA can also be an issue for shrinking, cracking or warping of wood.
- CCA is also recognized as being corrosive to some metal types meaning that galvanized metal fastenings should be used in combination with CCA applications.
- CCA contains highly toxic and carcinogenic substances with concerns for these substances reaching the natural environment CCA.

Chemical alternatives to PCP: **creosote**

- Produced from the distillation of coal tars and contains between 200-250 chemical species, although 85% of these are polycyclic aromatic hydrocarbons (PAHs).
- Widely used in the USA (16% of the utility pole market and 31% of all wood in the US as well as Canada.

REF: UNEP/POPS/COP.8/INF/20 - UNEP/POPS/POPRC.10/10/Add.1

Chemical alternatives to PCP: **creosote**

Advantages

- Like PCP, is an-oil based product used within industrial pressure treating of wood.
- The use of oil-based preservatives provides a waterproof layer to wood surfaces and to an extent also the metal fittings during service life, it also provides ‘suppleness’ to treated wood which can help prevent shrinking, warping and twisting, particularly in harsh climatic conditions.

Chemical alternatives to PCP: **creosote**

Disadvantages

- Concerns have been raised regarding health and environmental effects of creosote.
- The main constituents of creosote are PAHs which are already recognized as a POPs.
- The use of creosote has been in discussion for several decades because of the harmful impact on the environment and health of workers carrying out preservation.

REF: UNEP/POPS/COP.8/INF/20 - UNEP/POPS/POPRC.10/10/Add.1

Chemical alternatives to PCP: **copper naphthenate**

- Copper naphthenate is an oil-borne wood preservative.
- Produced as a mixture of copper salts and naphthenic acid, a by-product of petroleum refinery processes.
- Copper naphthenate has been approved for both industrial and domestic use in the US.
- Unlike CCA and creosote, copper naphthenate is not a registered pesticide and can be used in domestic applications in both the US and EU.

REF: UNEP/POPS/COP.8/INF/20 - UNEP/POPS/POPRC.10/10/Add.1

Chemical alternatives to PCP: **copper naphthenate**

Advantages

- Approved for above-ground, ground and freshwater use, but is considered unsuitable for coastal/marine applications. Equally, it can be used in the US within pressure-treating processes as can PCP, CCA and creosote.

Chemical alternatives to PCP: **copper naphthenate**

Disadvantages

- Quality issues experienced during the mid-1990s with specific batches of product have been quoted. Poles treated with these batches of copper naphthenate began to experience problems within four years of installation.
- Despite its wide use, the environmental profile and toxicity of copper naphthenate is poorly characterized. The petroleum product component can have the presence of multiple compounds including notably benzene.
- Like CCA, copper naphthenate leaches from wood and some studies on mice suggest that this substance may have potential to be genotoxic.

REF: UNEP/POPS/COP.8/INF/20 - UNEP/POPS/POPRC.10/10/Add.1

Chemical alternatives to PCP: **ammonical copper zinc arsenate (ACZA)**

- Aqueous product based on active ingredients in the ratio of 5:3:2 for cupric oxide, zinc oxide and arsenic acid, respectively.
- ACZA can be used in pressure treatment where evaporation of the ammonia fixes the metals compounds to the surface of the wood and additionally ammonia also provides corrosion protection of working metal parts in the tank itself during transfer of ACZA.

Chemical alternatives to PCP: **ammonical copper zinc arsenate (ACZA)**

Advantages

- ACZA, like CCA, has a high fixation rate.
- It can provide better performance than CCA in protection against some species of pest.
- Approved for use in coastal/marine applications with only a limited number of other approved preservatives.

Chemical alternatives to PCP: **ammonical copper zinc arsenate (ACZA)**

Disadvantages

- While CCA provides a clean, dry, odour-free finish to treated wood, ACZA treated wood tends to retain an ammonia odour.
- ACZA has the potential to leach from wood, including treated utility poles, it also has the potential to be toxic and an irritant on direct exposure for workers.
- Within the USA it is listed as a ‘restricted use pesticide’ reserved for industrial purposes.

REF: UNEP/POPS/COP.8/INF/20 - UNEP/POPS/POPRC.10/10/Add.1

Other alternative preservatives for wood treatment

Additional chemical alternatives exist:

- North America: Alkaline copper quaternary (ACQ), copper azoles and sodium borates (SBX) also form part of the mixture of wood treatment products available.
- Silicone polymers have been identified as a viable alternative.
- EU approved 32 active substances for use in wood preservative biocidal products. However, the vast majority are not used for industrial wood preservation.

REF: UNEP/POPS/COP.8/INF/20 - UNEP/POPS/POPRC.10/10/Add.1

Other alternative preservatives for wood treatment: **ACQ**

- Waterborne wood preservative used in a similar fashion to CCA.
- ACQ's widespread use has been focused within the domestic wood market and soft woods, due in part to the low occupational risk for workers and minimal risk of environmental loss.
- The use of ACQ would require the use of stainless steel fittings in treatment facilities which can be expensive.

Other alternative preservatives for wood treatment: **copper azole**

- Waterborne product made up of copper-amine complex and co-biocides.
- Similar to ACQ, the difference being that dissolved copper preservative is augmented by an azole co-biocide rather than the quat biocide used in ACQ.
- Like ACQ, copper azole is corrosive to metal fastenings and so stainless steel would be required, which can be expensive for treatment facility upgrades. However, a micronized copper azole product does exist with lower levels of corrosivity and potential for deeper penetration of wood.
- Copper azole is not known to be carcinogenic.

REF: UNEP/POPS/COP.8/INF/20 - UNEP/POPS/POPRC.10/10/Add.1

Other alternative preservatives for wood treatment: **sodium borates (SBX)**

- Waterborne preservative with varying amounts of borate.
- Sodium borates leave wood with clean, dry, odour-free finish.
- Sodium borates are reserved specifically for use within indoor applications or above ground where wood is continuously protected from water and, therefore, sodium borates are not an alternative for current PCP uses.

Non-chemical alternatives to PCP

- PCP-treated wood has particular application to infrastructure usage such as utility poles for electricity supply networks and cross-ties for rail networks. These specific applications can adopt alternative materials such as:
  - Concrete
  - Steel
  - Fibreglass reinforced composite (FRC)
  - Heat-treated wood
  - Hardwood alternatives

Non-chemical alternatives to PCP: **concrete**

Advantages

- Concrete utility poles and cross-ties provide a standardized product with high tensile strength and durability, and greater resistance to damage from lightning strikes, fires, vibration, fungal and insect pests and wind.
- Enhanced durability in ideal locations, less frequent maintenance and potentially longer service life than chemically-treated wood demonstrated a high level of efficacy in meeting the structural needs of utility poles.
- Doesn't require chemical treatment, thus conferring benefits to workers and environmental health.

REF: UNEP/POPS/COP.8/INF/20 - UNEP/POPS/POPRC.10/10/Add.1

Non-chemical alternatives to PCP: **concrete**

Advantages

- Strong durability of concrete poles and standardized formulation can be a key factor in maintaining a long service life and preventing the failure of poles at a premature point.
- Forest ecosystem protection and conservation of trees are additional benefits.
- Because of their corrosion resistance, durability and lack of chemical treatment, they are used in proximity to sensitive water bodies and can be used in freshwater and saltwater environments.

Non-chemical alternatives to PCP: **concrete**

Disadvantages

- The most significant issue for concrete compared to treated wood is weight.
- Cement and concrete come from finite resources that must be excavated (potential environmental impacts in the production of cement).
- Some studies conclude that in comparison to wood-based products, the manufacture of concrete posts has a greater demand for natural resources such as water, and importantly are linked to much higher carbon dioxide and air quality pollutant emissions.

Non-chemical alternatives to PCP: **steel**

Advantages

- Steel utility poles are manufactured as hollow structures, which allow them to be lighter than treated wood poles (by 30-50%) with similar or greater load bearing strength.
- Can be recycled or used again as needed.
- Steel railway cross-ties have a lesser reliance on ballast.
- Steel is also sturdier than timber and less expensive than pre-stressed concrete.

Non-chemical alternatives to PCP: **steel**

Disadvantages

- Steel poles can be open to surface corrosion which can be difficult to assess by maintenance crews, and are also susceptible to below ground corrosion.
- They need to be handled with care during transport and installation as they can be easily damaged.
- Increased risk of electrocution not only to animals but also work crews.
- Manufacture of steel poles requires greater consumption of natural resources such as water, and is linked to higher emissions of carbon dioxide and air pollutants.
- Steel railway cross-ties are susceptible to corrosion and lack insulation.

Non-chemical alternatives to PCP: **fibreglass reinforced composite (FRC)**

Advantages

- FRC provides a standardized material with known specifications.
- FRC poles are lighter than treated wood.

Non-chemical alternatives to PCP: **fibreglass reinforced composite (FRC)**

Disadvantages

- FRC-based products can distort when screwing down hardware and therefore the mounting hardware may loosen over time making FRC generally not appropriate for loadbearing components such as poles and cross-arms.
- FRC poles may also be more susceptible to UV radiation.
- Energy demand requirements to produce FRC poles are greater than treated wood alternatives and that FRC poles will have a greater carbon footprint than treated wood.

Non-chemical alternatives to PCP: **heat-treated wood**

- This approach uses thermal treatment of wood near or above 200°C in low oxygen conditions to make it resistant to decay while maintaining dimensional stability.
- Principal uses are restricted to above ground non-structural uses. Thus, heat treated wood is not a viable alternative to current uses of PCP.

REF: UNEP/POPS/COP.8/INF/20 - UNEP/POPS/POPRC.10/10/Add.1

Non-chemical alternatives to PCP: **hardwood alternatives**

- Hardwood varieties can have a viable service life of up to 25 years in the US without the need for chemical treatment.
- The main issue for greater use of hardwood varieties will be the availability of viable stock which will vary globally.
- The use of hardwood varieties will have varying efficacy based on climatic conditions, application and availability of suitable stock. This is offset by the enhanced benefits of reduced chemical use and emission to the environment compared to PCP-treated wood.

Final remarks

- There are several viable chemical alternatives to PCP for wood preservation and non-chemical alternatives to wood for utility poles and railway ties.
- A number of considerations are important in the process to control and minimize the environmental emissions of PCP, including identifying issues at national level and engagement with relevant stakeholders. This also provided an exhaustive list of possible viable policy and technical control options to help manage and minimize the emissions from existing use of PCP; as well as promote the phase-out of PCP for safer alternatives.