Preliminary Inventory Assessment of PCNs, SCCPs and PCBs[1] in South Africa

The report was developed within the Project on "Supporting inventories development and priority setting as part of the process to develop, review and update NIPs -National Implementation Plans- for POPs listed after the entry into force of the Stockholm Convention".

Draft 08/2019

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[1]PCBs in open application. PCB in closed applications in South Africa is not addressed here since they are addressed in a separate GEF project (GEF Project ID 9576). But this report consider the link to this project where appropriate.

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Abbreviations and acronyms

BBP	Butyl benzyl phthalate
BFR	Brominated flame retardant
BR	Polybutadiene rubber
CAS	Chemical Abstracts Service
CSM	Conceptual site model
CR	Chloroprene rubber
DBP	Dibutyl phthalate
DDT	Dichlordiphenyltrichlorethan
DEHP	Bis(2-ethylhexyl) phthalate
DIDP	Diisodecyl phthalate,
DINP	Diisononyl phthalate
DNOP	Di-n-octyl phthalate
DSI	Detailed site investigation
ECD	Electron Capture Detector
ECHA	European Chemical Agency
ECNI	Electron capture negative ionization
EDC	1,2-Dichloroethane
EPDM	Ethylene propylene diene monomer
ESM	Environmentally Sound Management
EU	European Union
EVA	Ethylene-vinyl acetate
FR	Flame Retardant
GC	Gas chromatography
HBCD	Hexabromocyclododecane
HCB	Hexachlorobenzene
HCBD	Hexachlorobutadiene
HCH	Hexachlorocyclohexane
ISO	International Organization for Standardization
LCCPs	Long-chain chlorinated paraffins
MCCPs	Medium-chain chlorinated paraffins
MS	Mass spectrometer
MWF	Metal Working Fluid
NBR	Acrylonitrile and butadiene rubber
NR	Natural rubber
PBDEs	Polybrominated diphenyl ethers
PBTs	Persistent, bioaccumulative and toxic substances
PCBs	Polychlorinated biphenyls
PCDDs	Polychlorinated dibenzo-*p*-dioxins
PCDFs	Polychlorinated dibenzofurans
PCNs	Polychlorinated naphthalenes
PCP	Pentachlorophenol
POPs	Persistent Organic Pollutants
PVC	Polyvinylchloride
RAPEX	Rapid Alert System for Non-Food Consumer Products (EU)
SBR	Styrene and butadiene rubber
SC	Stockholm Convention

SCCPs	Short-chain chlorinated paraffins
UNECE	United Nations Economic Commission for Europe
UNEP	United Nation Environment Program
UNIDO	United Nation Industrial Development Organisation
USEPA	United States Environmental Protection Agency
UPOPs	Unintentionally produced POPs
VCM	Vinyl chloride monomer

1 Introduction and Background

1.1 Background on PCNs and link to PCBs

In May 2015, by decision SC-7/14, the Conference of the Parties to the Stockholm Convention on Persistent Organic Pollutants (POPs) amended Annex A to the Convention to list polychlorinated naphthalenes (dichlorinated naphthalenes to octachlorinated naphthalene, referred to as PCNs). PCNs were listed with specific exemptions for production of those chemicals as intermediates in production of polyfluorinated naphthalenes, including octafluoronaphthalene, and the use of those chemicals for the production of polyfluorinated naphthalenes, including octafluoronaphthalene. PCNs were also listed as unintentional POPs in Annex C to the Convention.

PCNs were first produced for technical use around 1910 with major production from the 1930s to 1960s and declining production in the 1970s. The production of PCN mixtures is assumed to have ended around 2000 with the exception of production of PCNs as intermediate for the production of polyfluorinated naphthalenes (PFNs). The production of technical PCNs mixtures stopped around 2000 (UNEP 2017a, 2019###).

Major uses of PCNs were in cable coatings, rubber, paints, sealants, and capacitors (Table 1). Due to the early use of PCNs, most products containing PCNs have most likely been disposed. For some long-term uses like sealants and paints in construction and ships, some PCNs might still be present. For the more recent use of PCNs in rubber (until 2000), some of the products might still be in use. Only a few measurements of PCNs in open applications have been published. For example, PCNs in Neoprene FT rubber (Yamashita et al. 2003), or PCNs in waste wood (Koyano et al. 2019). There are no studies on specific monitoring of PCNs in closed applications such as capacitors or transformers. However, some measurements of technical PCB oils from transformers showed that PCBs contain unintentional produced PCNs (Yamashita et al. 2000).

The main use of PCNs were practically identical to the uses of PCBs in closed applications (e.g. capacitors, transformers) and open applications (e.g. cables, paints/coatings, sealants). The total production volume of PCBs was, however, approximately 10 times larger (ca. 1.5 million tonnes) compared to PCNs (ca. 150,000 tonnes). Therefore, the inventory of PCNs should be linked or combined with the inventory of PCBs.

A draft inventory guidance for PCNs has been developed by the Secretariat of the Stockholm Convention and it includes information on PCBs in open applications (UNEP 2017a, 2019a).

PCNs and PCBs are also formed as unintentional POPs in certain processes of the organochlorine (e.g. production of chlorinated paraffins) and chlorine industries, and in incineration processes and are therefore listed also in Annex C. Table 2, shows the concentrations of PCNs (or PCBs) in selected applications and some waste fractions.

PCNs and PCBs were substituted by chlorinated paraffins (CPs) in many open applications that are still produced and where short-chain chlorinated paraffins have been listed as POP in 2017 (see Chapter 1.2). Therefore, the most appropriate approach is an assessment/inventory of PCNs combined with that of PCBs and SCCPs.

Table 1: Former PCN uses in closed and open applications (UNEP 2019a)

Sector	Application
Transformers and Capacitors	• Capacitor impregnates (Jacobsson & Asplund 2000) • Transformer and capacitor fluids (UNECE 2007; IPCS 2001)
Batteries	• Separator in storage batteries (Jacobsson & Asplund 2000)
Plastics and cables	• Cable covering (flame-retardants) (Jacobsson & Asplund 2000) • Additive in plastic (Jakobsson & Asplund 2000)
Rubber	• Additive in Neoprene and possibly other chloroprene with use in printer belts (Yamashita et al. 2003; Yamamoto et al. 2018)
Sealants	• Water proof sealants (NICNAS 2002)
Paints, lacquers, dyes/dye carrying agents	• In anti-corrosion/underwater paints and lacquers (Jacobsson and Asplund 2000)
Wood preservative/fungicide	• Impregnation of wood (IPCS 2001; Jakobsson & Asplund 2000)
Textile and paper industry	• Coating/impregnation of paper and textiles for water proofing (Van de Plassche and Schwegler 2002, Jakobsson & Asplund 2000)
Oil additives and lubricants	• Additives in oils for lubrication in gear and machinery (Jakobsson & Asplund 2000; US Department of Agriculture 1954) • Oils in mining sector (Popp et al. 1997) • Cutting oils (Jakobsson and Asplund 2000) • Engine oil additive (Van de Plassche and Schwegler 2002) • Refracting index testing oils (Van de Plassche, Schwegler 2002)
Military use	• Fogg ammunition; smoke grenades (Generalstab Schweizer Armee 1945; EMPA 2006). • Inert artillery and mortar projectiles (Hewitt et al. 2011; Clausen et al. 2004; Falandysz 1998) • Paints for ships (Redfield et al. 1952) and possibly other metal surfaces of military vehicles/equipment.

Table 2: Concentration of PCNs (or PCBs)* in selected application and some waste fractions

Product/sample (POPs measured)	Level of PCN or PCB (mg/kg)	References
Neoprene rubber (PCN)	36,000 – 45,000	Yamamoto et al. 2005 Yamashita et al. 2003
Rubber coated plastic (PCN)	1000	Yamashita et al. 2003
Rubber belt for printers (PCN)	41 to 2000 (3/21)	Yamamoto et al. 2005
Rubber belt for printers (PCN)	0.001 – 0.1 (17/21)	Yamamoto et al. 2005
Aerosol adhesives (PCN)	1150 – 1200	Yamashita et al. 2003
Sealants (PCB)*	28,000 – 224,000	Kohler et al. 2003
Paints (PCB)*	30,000 – 160,000	Weber et al. 2018a
Cable sheathing and coating (PCB)	30,000 to 200,000	Mueller 2017
Cables coatings in recycling (PCB)*	10 – 325	Lehnik-Habrink et al. 2005
Automotive shredder residue (PCN)	0.026 – 0.040	Yamamoto et al. 2005
Refused derive fuel (PCN)	0.011 – 0.086	Yamamoto et al. 2005
PCN (technical mixture)	930,000 – 1,000,000	Yamashita et al. 2003
Transformer oils (Askarel PCB)*	ca. 600,000**	Mueller 2017
Contaminated transformer oil (PCB)*	50 – 100,000	Mueller 2017
Capacitor/condensers (PCB)*	ca. 600,000**	Mueller 2017
Transformer oils (unintentional PCNs)	1000 – 9000	Yamashita et al. 2000

*For these applications only PCB data were available. Due to the use in the same application and similar chemical properties, the levels of PCB use might reflect levels if PCN was/are used.

**The PCBs are normally mixed with ca. 300,000 mg/kg PCBz.

1.2 Background on SCCPs and other CPs and link to PCNs

Short-chain chlorinated paraffins (SCCPs) (chain length C10 to C13) together with medium and long-chain chlorinated paraffins (MCCPs and LCCPs) have substituted PCBs and/or PCNs in a range of open applications (e.g. cables/PVC, sealants/adhesives, paints/coatings, cutting oils, rubber) since the 1970s. SCCPs were listed as POPs in the Stockholm Convention in 2017. In May 2017, by decision SC-8/11, the Conference of the Parties amended Annex A to the Convention to list short-chain chlorinated paraffins (SCCPs) with various specific exemptions.

Parties to the Convention for which the amendments to list PCNs and SCCPs have entered into force shall meet the obligations under the Convention leading to the elimination of those chemicals. According to Article 7 of the Convention, each Party shall develop national implementation plan (NIP) within two years from the date of entry into force. The establishment of inventories is one of the important phases in the development of NIPs. Furthermore, Article 6, paragraph 1 (a), of the Stockholm Convention requires each Party to develop appropriate strategies for the identification of products and articles in use and wastes consisting of or containing or contaminated with POPs. MCCPs and LCCPs are not listed in the Convention and are not restricted However, it is cautioned by science that MCCPs are also bioaccumulative, toxic to the aquatic environment, and persistent in the environment (Glüge et al. 2018).

The total global production volume of all CPs is more than 1 million tonnes per year (Glüge et al. 2016). It is estimated that this includes production and used of about 165,000 t of SCCPs (Glüge et al. 2016). The major use is in open applications such as plasticizer or flame retardant in PVC/other plastic, rubber, paints, sealants/adhesives, leather fatliquoring, lubricants and metal working fluids. Many of these uses were exempted in the Stockholm Convention listing (Table 3). These were also the major historic uses and, therefore, from the last 50 years production, stockpiles and products in use and wastes have likely accumulated over time.

SCCPs (chain length C10 to C13) can be present as impurities in MCCPs (C14 to C18). If the SCCP content in MCCPs is above 1%, this mixture is considered also a POP. Therefore, for an inventory of SCCPs, MCCPs also need to be assessed and analysed. This needs monitoring and analysis since only by this approach it can be decided if a chlorinated paraffin in a use or product contains SCCPs or is contaminated by SCCPs or if it contains other chlorinated paraffins not listed in the Convention.

Due to the concerns on the persistence and bioaccumulation of MCCPs (Glüge et al. 2018), the exposure and release of MCCPs need also to be controlled. Recent studies have shown that MCCPs and to a lower extent SCCPs are released in 50% of baking ovens in Germany (n=20) and are released from many kitchen/food-blenders (Gallistl et al. 2018; Yuan et al. 2017). Since MCCPs might contain SCCPs as constituents or as impurities, MCCP uses need to be monitored within the assessment of SCCPs.. This approach will clarify the POPs properties and assess MCCP use and substance flow for SCCP assessment. Such an assessment can lead to a more sustainable use of MCCPs and the improvement of its current use. A sustainable and controlled use of MCCPs that reduces and possibly minimizes releases of MCCP (and associated SCCPs) into the environment should be encouraged in order to avoid high human and biota exposures. This will most likely form the basis to avoid future restriction of MCCPs, as suggested, e.g. by the Swedish Kemi for electronic equipment for listing into the RoHS list (KEMI 2018).

Table 3: Specific exemptions for short-chain chlorinated paraffins

Chemical	Activity	Specific exemption
Short-chain chlorinated paraffins (Alkanes, C_{10-13}, chloro): straight-chain chlorinated hydrocarbons with chain lengths ranging from C_{10} to C_{13} and a content of chlorine greater than 48%, by weight For example, the substances with the following CAS numbers may contain short-chain chlorinated paraffins: CAS No. 85535-84-8; CAS No. 68920-70-7; CAS No. 71011-12-6; CAS No. 85536-22-7; CAS No. 85681-73-8; CAS No. 108171-26-2. CAS No. 63449-39-8	Production	As allowed for the Parties listed in the Register
	Use	• Additives in the production of transmission belts in the natural and synthetic rubber industry; • Spare parts of rubber conveyor belts in the mining and forestry industries; • Leather industry, in particular fatliquoring in leather; • Lubricant additives, in particular for engines of automobiles, electric generators and wind power facilities, and for drilling in oil and gas exploration, petroleum refinery to produce diesel oil; • Tubes for outdoor decoration bulbs; • Waterproofing and fire-retardant paints; • Adhesives; • Metal processing; • Secondary plasticizers in flexible polyvinyl chloride, except in toys and children's products.

1.3 Science-Policy Support - monitoring and assessment of PCNs, PCBs and SCCPs

1.3.1 Background

The science-policy interface is of key relevance for science based decision making which is stressed by the Basel, Rotterdam and Stockholm (BRS) Convention with a road map from science to action presented at COP 2017 and 2019 (UNEP 2019d).
The science base for policy making includes e.g. inventories and material and substance flow analysis, quantitative data on pollution, or science based limits for exposure or regulatory action. The integration of researchers groups or governmental institutions with analytical capacity in the development and implementation of the NIP is, therefore, of key importance. For a range of POPs, the assessment/inventory and the implementation of the convention need monitoring and measurement data.
There is relative good information on PCBs in open applications in industrial countries (Jartun et al. 2009; UNEP 2019e; Wagner et al. 2014) including the relevance of contamination of environment, food and humans (Weber et al. 2018a,b). There are hardly any data and information on PCBs in open applications in developing countries. Most PCB data from developing countries are from GEF projects on measuring of PCBs in closed applications in particular transformers. However, after more than 10 years inventory work, many developing countries have concentrated on screening of PCBs in transformers and often have not yet addressed capacitors.
As described above, PCNs have also been used in the same open and closed applications as PCBs (UNEP 2019a). However, there are only a few measurements on PCNs in open application (e.g.

Neoprene FT, Yamashita et al. 2003) and there are no data on PCNs in closed applications other than as unintentional POPs in PCB oils (Yamashita et al. 2000).
Also for SCCPs (including SCCPs in MCCPs) only initial monitoring data have been generated in some monitoring projects in Europe (Gallistl et al. 2018; UNEP 2018; Yuan et al. 2017). To date, there are no data on SCCPs in products in Africa and other world regions.
Therefore, it needs some screening and monitoring and a strategic use of research/monitoring capacity to assess and understand the presence of PCNs and PCBs and the substitute SCCPs in the different uses and waste and recycling flows. Inventory guidance documents have been developed for PCNs (UNEP 2019a) and for SCCPs in 2019 (detailed version UNEP 2019b and short version UNEP 2019c to support assessment. These guidance documents also include information on PCBs in open application.

1.3.2 Need of monitoring data and approach

PCNs in open applications need to be analysed to finally confirm their presence in a product as highlighted for PCBs in open applications (UNEP 2019e). Otherwise it is not possible to confirm if a sealant or a rubber contain these POPs pollutants or not. There is a global gap on information of the presence of PCNs in open application worldwide even in industrial countries where a few monitoring studies have been conducted and published, e.g. for Japan (Koyano et al. 2019, Yamamoto et al. 2018; Yamashita et al. 2003). However, there is no single dataset of PCNs or PCBs in open application in developing countries.
Also there is a complete knowledge gap on PCBs in open applications in developing countries including the entire African continent. Since PCBs have been used in higher volumes than PCNs in history but in basically the same uses, it is wise and practical to combine the screening of PCBs and PCNs for POPs inventories. Since CPs have substituted PCNs and PCBs in open applications, and SCCPs are listed as POPs since 2017, the most appropriate approach is a combined assessment of PCNs, PCBs and SCCPs. Since CPs contain PCNs and PCBs as unintentional POPs (Takasuga et al. 2012), this assessment should also address the presence of unintentional PCNs and PCBs in SCCPs and other CPs with appropriate measurements. Also the content of SCCPs in CP mixtures should be determined to decide on POPs categorisation.
A useful inventory of PCNs, PCBs and SCCPs, therefore needs monitoring and analysis (Tier III assessment). Therefore, for a reasonable inventory analytical capacity need to be involved either by cooperation with existing laboratories or by the development of analytical capacity.

1.3.3 Steps to establish analytical capacity

To develop analytical capacity and generate data in the current project, the following approach and steps were taken.

A) Contact/involvement of research groups with experience in PCN and SCCP analysis

In the preparation of the country pilots, research groups with capacity to analyse PCNs and SCCPs were contacted and asked for support. The very limited budget of this project did not allow a budget for analytical cost but only voluntary contributions. Research groups were contacted for discussion including the Japanese National Institute for Environmental Science (Dr. Natsuko Kajiwara). Prof. Takeshi Nakano (Osaka University, Japan), Professor Walter Vetter and Jannik Sprengel (Hohenheim University, Germany), Dr. Guroi Liu (Chinese Academy of Science), Professor Joao Torres and Yago Guida (Rio University, Brazil).

B) Involvement of research groups for inventory and assessment of respective POPs

One bottleneck of POPs assessment and management in developing or transition economies is the limited analytical capacity in developing countries. Therefore, the approach in this project was the establishment of analytical and research capacity for PCNs and SCCPs in the country.

Such capacity and involvement of research groups contributes to the improvement of knowledge in the science community of a country and the science-policy dialogue with related strengthening of the science-policy interface.

In the pilot countries the research groups were assessed for potential partners and selected (see 1.4).

C) National capacity building and research development and development of a PhD programme

To get reliable results, a robust monitoring and analytical method need to be established. This was done by selecting cooperation partners developing the standard procedures in respective industrial countries. In South Africa and Brazil, the research groups have started to establish PhD programmes or integrated the topic in an ongoing PhD programme. The Brazilian student (Mr. Yago Guida) had already been trained in Germany (Prof. Walter Vetter group) for SCCP analysis in the frame of another project and was capable to establish the SCCP and PCN analysis at Rio University in Brazil.

The Brazilian group (Mr. Yago Guida) together with the group of Professor Vetter (Jannik Sprengel) have developed Standard Operation Procedure for the GC/LRMS analysis of PCNs (see Annex 2) and SCCPs (See Annex 3)

In South Africa capacity is being built with the support of research groups at Tshwane University (Prof. Jonathan Okonkwo, Dr. Peter Daso). A PhD student, Ms Vhodou Nevondo, has developed a proposal for her PhD programme on qualification and quantification of PCNs and SCCPs in selected consumer products using XRF and GC-MS/MS and a first short paper has been written and was presented at the global POPs conference (Annex 4).

1.4 Approach for developing a preliminary inventory and building the bases for detailed assessments

1.4.1 Involvement of research groups and building knowledge and analytical capacity

In South Africa several research groups possess some capacity for POPs analysis. The most suitable group already analysing POPs in the technosphere with available XRF equipment was the group of Prof. Jonathan Okonkwo from Tshwane University (Pretoria) [2]. Also other laboratories/research groups in South Africa were contacted. None of them had an established PCN or SCCP analysis or were planning to establish that analysis.

The research group of Professor Jonathan Okonkwo had already analytical capacity for several POPs including PCBs, PBDEs and PFOS/PFOA. However, in the beginning of the project analysis of PCNs and SCCPs where not developed in his group and also not in any other research group or analytical laboratory in South Africa.

The Department of Environmental Affairs of South Africa decided to involve two research groups headed by Prof. Jonathan Okonkwo (expertise in environmental analyses of POPs in different

[2] https://www.researchgate.net/profile/Okechukwu_Okonkwo

environmental matrices) and Professor Henk Bouwman (expertise in environmental monitoring of biota) to determine background concentrations of PCNs and SCCPs (and PCBs) in South Africa. After initial discussion, Professor Okonkwo agreed to set up plan to develop the analysis of PCNs (listed 2015) and SCCPs (listed 2017) (see Chapter 9). Finally, a motivated PhD student, Ms V Nevondo, was found and introduced to the subject.

1.4.2 Initial monitoring of selected samples

Within the limited time, initial samples have been selected for a first screening of the presence of SCCPs, PCNs and PCBs. For the screening, a X-ray fluorescence (XRF) product testing was started by Prof. Jonathan Okonkwo's group (Tshwane University, Pretoria).
Prior to use, the XRF was calibrated using calibration check (pass/fail) 316 stainless steel coupon, followed by the measurement of polymeric check standards (ERM-EC680 and- EC681) through the Mylar window of the plastic cup. The instrument was triggered for 120 s in order to verify the instrument's reliability and accuracy. XRF in the RoHS/WEEE mode triggered for 60 s during each measurement was used to measure chlorine contents of randomly selected 21 items of consumer products.
As a start the following accessible consumer products. were sampled and subjected to XRF (Olympus Innov-X DELTA XRF analyser): sealants, polyvinyl chloride (PVC) cable insulation, plugs and pipes at Tshwane University of Technology, Arcadia campus. Chlorine concentration was identified and measured which may indicate the presence of chlorinated additives in the consumer products.

1.4.3 Gap analysis and developing research/monitoring project proposal for next inventory phase

This initial study did not have the time, resources and capacity to develop a detailed inventory of SCCPs and PCNs which are addressed for the first time in a developing country and need monitoring and analysis. Even for industrial countries such inventories do not exist yet. Only initial monitoring of selected product categories is currently conducted e.g. in Japan where recently the first study on PCNs in waste wood was conducted and published (Koyano et al. 2019) and PCN contaminated rubber was destroyed (Yamamoto et al. 2018).
Therefore, the terms of reference of this project included the request to conduct a gap analysis and the need of future screening and monitoring of PCNs/PCBs and SCCPs in the South Africa. For this a PhD thesis is envisaged to emanate from the study. Based on the gap assessment (Chapter 8 and throughout the report) a research project can be developed which can contribute to a robust inventory of SCCPs, PCNs and possibly PCBs in open applications in South Africa possibly with selected samples from neighbouring countries.
Samples for the screening have been compiled in the gap analysis of the preliminary inventory for potentially contaminated product categories (Chapter 8).

1.5 Structure of the report

In this report information on the potential and likely uses of SCCPs, PCNs and PCBs (in open application) in South Africa has been compiled. A gap analysis was conducted and samples for monitoring of SCCPs and PCNs in import and export, productions, products including consumer products and products used in industry were chosen. Also information on end of life management and recycling was compiled.

1.5.1 Assessment of presence and likely presence of PCNs and SCCPs (Tier I and Tier II)

The production, import and export of PCNs and SCCPs is assessed in Chapter 2. An assessment of production in South Africa that uses PCNs, PCBs and SCCPs for open applications was conducted within this project (Chapter 3).

Information on consumer products on the market possibly containing SCCPs, PCNs and PCBs are compiled in Chapter 4.

It is suggested that the first assessment of PCNs in closed applications is included within the current GEF project on PCB inventory and management activities in the SADC region (GEF Project ID 5532) and upcoming PCB inventory and management activities in South Africa within a GEF Project (see Chapter 5; GEF Project ID 9576).

Also an initial assessment of potential generation of unintentional PCNs was conducted (Chapter 6). Initial findings on potentially PCN and SCCP contaminated sites in South Africa are described in Chapter 7.

For all sources a gap analysis and the need for monitoring and research for further inventory development is compiled in Chapter 8 with a compilation of samples which could be selected for a Tier III inventory.

1.5.2 Support for establishing PCN and SCCP analysis for Tier III inventory

As support for the establishment of PCN and SCCP analysis, contacts were established to experienced research group for PCN and SCCP analysis including the research group of Professor Vetter supervising a PhD student on the development of SCCP analysis for the national European food and feed laboratories and Dr. Natsuko Kajiwara responsible for development of PCN and SCCP analysis at the National Institute of Environmental Studies (NIES) for Japan. Furthermore the contact was establishes between the researchers in South Africa and Brazil.

The Rio University group (Yago Guida, Prof. Joao Torres) in cooperation with Hohenheim University (Professor Vetter; Jannick Sprengel) developed a Standard Operation Procedure for setting up analysis of SCCPs (Annex 3) and for PCNs (Annex 2). For the Standard Operation Procedure (SOP) for PCNs also the Stockholm Convention guidance for monitoring POPs in products was considered (Secretariat of the Stockholm Convention 2017).

2 Assessment of production import and export of PCNs and SCCPs

Countries that are producing PCNs or SCCPs or have formerly produced PCNs or SCCPs (also MCCPs possibly containing SCCPs) would compile data on the current and historic production taking into account how to treat confidential business information (UNEP 2019 a,b,c).
Information on the amount of related current and former production of wastes and the historic management and disposal of wastes containing PCNs and SCCPs should be gathered within the inventory process. The information on stocks of PCNs and SCCPs from current and former producers and users should be noted and included in the inventory (UNEP 2019 a,b,c).

2.1 Production of PCNs

Parties to the Stockholm Convention shall prohibit and/or eliminate the production of PCNs, except if they have notified the Secretariat of their intention to utilize the time-limited specific exemption for production and use of PCNs as intermediate for the production of polyfluorinated naphthalenes, as provided in Annex A to the Convention (UNEP 2019a). The Party registering the specific exemptions should provide to the Secretariat the information on the production and use of PCNs. Only Russia has asked for exemption for production of PCNs for PFN production.
There is no indication of current or former intentional production of PCNs in South Africa. The visit to NCP Chlorchem (Pty) Ltd; (Address CNR Allendale & Chloor road, Chloorkop) the main and rather only chlorine and organochlorine producer in South Africa indicated that no PCNs are produced or have been produced in the past. It needs to be stressed that the company has produced POPs in particular lindane/HCH in the past which is however not a topic of the current study. The total amount of waste HCH was several 10000 tonnes of HCH which was disposed at the production site and recently moved to a nearby landfill.
The company operates and operated processes that might have produced and produce unintentional PCNs (e.g. chlorine production and production of chlorinated paraffins; UNEP 2019a).

2.2 Production of SCCPs

The visit to the main and rather only organochlorine producer in South Africa - NCP Chlorchem (Pty) Ltd; (Address CNR Allendale & Chloor road, Chloorkop) - revealed that the company is producing and has produced chlorinated paraffins. According to the company they are not producing SCCPs and have never produced SCCPs but only MCCP (see below).

2.3 Production of MCCPs and LCCPs and related SCCP contamination

MCCPs and LCCPs can be contaminated with SCCPs. If the SCCP concentration is >1% , the MCCPs/LCCPs are considered contaminated with SCCPs and are classified as POP or POPs waste. NCP Chlorchem (Pty) Ltd. (Address CNR Allendale & Chloor road, Chloorkop) informed that they are producing chlorinated paraffins. The company stated that:

- Only medium chain chlorinated paraffins are produced and have been produced in the past
- The producer of the paraffins is Sasol (South Africa)[3]. Sasol guarantees that the content of C13 and lighter is maximum 0.99% and typical concentration is 0.5% (Sasol 2003).

[3] https://products.sasol.com/pic/products/home/grades/AS/5c14-c17-n-paraffin/index.html

The chlorination of such paraffin mixtures should result in MCCPs containing less than 1% SCCP with a typical SCCP concentration of 0.8% (8000 mg/kg).

Gap assessment:

There were no measurements of SCCPs in MCCPs available.

After SCCP analysis is established at Tshwane University, some MCCP samples from NCP Chlorchem (Pty) Ltd. should be analysed for SCCPs.

2.4 Import of SCCPs and MCCPs/LCCPs possibly containing SCCPs

According to the information from the meeting of NCP Chlorchem (Pty) Ltd., chlorinated paraffins are imported into South Africa, e.g., from India. The company mentioned that these products might even be cheaper than the South African products despite the transport from India. It is not known if these CP-mixtures contain SCCPs and at what concentration they contain SCCPs.

For imports and exports HS codes give information on product categories and sometimes even on the imported chemicals. Currently the SCCPs do not have specific Harmonized System (HS) codes as for most other industrial POPs (Korucu et al. 2015). Therefore, HS codes cannot be reliably used for assessing import quantities of SCCPs at the moment. But they can give an indication (Tier I) and can be used for further assessment by Tier II and III approaches (UNEP 2019b,c).

Experience has shown that chlorinated paraffins are exported/imported under different HS codes compiled in Table 4.

These codes are however not specific for SCCPs and are also not specific for the class of chlorinated paraffins. However in some countries additional information might be included in the import documents which can inform if individual imports/exports under these HS categories are chlorinated paraffins.

For export of chlorinated paraffins from India, detailed information is available including the countries to which CPs have been exported. The amount of export of CPs from India to South Africa for 02/2013 to 11/2016 is compiled in Figure 2. Every month about 100 tonnes of chlorinated paraffins are imported from India to South Africa (Figure 2). In total 3891 tonnes of chlorinated paraffins were imported to South Africa from India in approximately 4 years (Figure 2). The CP production amount of China is more than 3 times the production of India. Also the average imports of chemical products and materials from China to South Africa are normally higher than from India. Therefore, the overall import of CPs to South Africa is likely more than 2000 tonnes per year.

However, it is unknown which share of SCCPs are included in these CP imports. If the imports were according to the estimated share of SCCPs of global CP production volumes (approx. 16%) (Glüge et al. 2016) then it would be estimated that at least 320 t of SCCPs as CP-products are imported to South Africa every year. Furthermore, more SCCPs are imported to South Africa in products (see Chapter 3). It is necessary to measure the imported CPs to clarify the share of SCCPs in these imports.

Table 4. HS Codes under which chlorinated paraffins and other paraffins are imported

HS Codes	Classification
382490	Chemical products and preparations of the chemical or allied industries, not elsewhere specified or included

271220	Paraffin wax; containing by weight less than 0.75% of oil, obtained by synthesis or by other processes, whether or not coloured
271290	Paraffin wax; containing by weight 0.75% or more of oil, obtained by synthesis or by other processes, whether or not coloured
381220	Plasticisers, compound; for rubber or plastics

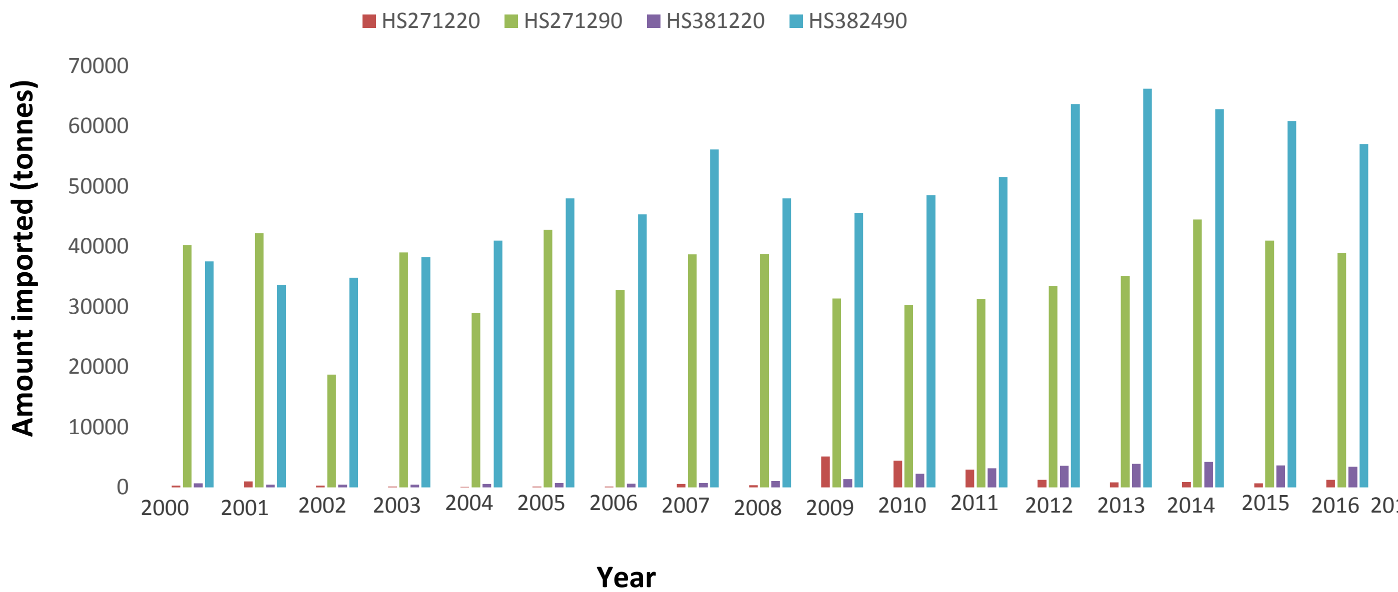

Figure 1. Import of HS codes of paraffin products (see Table 4) under which also CPs are imported.

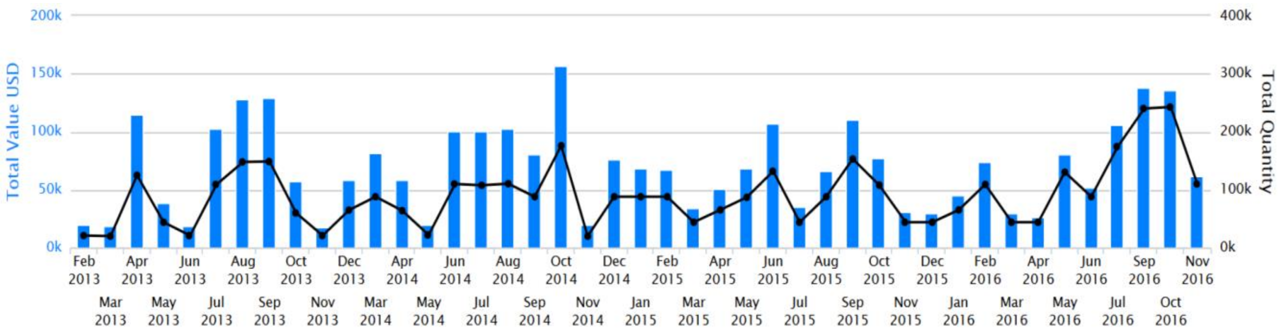

Figure 2. Import of chlorinated paraffins from India to South Africa (2013 to 2016) (Zauba Technologies).

3 Assessment of PCNs, PCBs and SCCPs in the production and in industrial products

3.1 Background on PCNs and SCCPs in products

A major use volume of PCNs were in open application such as cables, paints, sealants/caulks and putty, chloroprene rubber, wood preservatives, paper, textiles (UNEP 2019a). As mentioned above, major PCN production and use was from the1930s to 1960s and production declined in the 1970s. The production of PCN mixtures is assumed to have ended around 2000 with the exception of production of PCNs as intermediate for the production of polyfluorinated naphthalenes (PFNs). Depending on the time span when PCNs were used in the individual applications and the half-life of these products, most of the products/articles might have entered end of life. Some PCN applications which are more recent (e.g. paints and chloroprene rubber) and have longer half-lives (cables, sealants or putty in buildings) may be (partly) still in use and in products (UNEP 2019a).

As described in chapter 3.2 of Stockholm Convention PCN inventory guidance, PCBs were also used in a range of open applications where PCNs were used (UNEP 2019a). Since PCBs in open applications have not been systematically addressed within Stockholm Convention inventory activities yet, they are included here in chapters where PCB use might be relevant. For several of this uses, PCBs have been used in larger volumes compared to PCNs.

SCCPs and other CPs have substituted PCNs and PCBs in major uses (rubber, sealants/adhesives, paints, plastic additives, lubricants) (UNEP 2019b,c).

Also some other POPs have been used in these open applications and can be assessed at the same time. This has recently be done e.g. for waste wood in Japan where PCNs, PCP, and other POPs pesticides have been analysed (Koyano et al. 2019).

For the inventory of products it needs to be considered that the uses of industrial mixtures of PCNs/PCBs in open applications have stopped, but that there are still stocks of former uses (sealants in buildings or paints in construction). However, SCCPs are still produced and used until today. Furthermore it needs to be considered that unintentional PCNs and PCBs can be contaminants in SCCPs and other CPs (Takasuga et al. 2012) and therefore also products containing CPs might contain PCNs or PCBs, however in much lower concentration (e.g. the CPs investigated by Takasuga et al. 2012a contained PCNs and PCBs in 100 mg PCNs/PCBs per kg CPs).

3.2 PCNs, SCCPs, PCBs and other POPs in cables

3.2.1 Background of PCNs, PCBs and SCCPs in cables

The use of PCNs as flame retardants in cables and cable sheaths was a major use of PCNs (Jacobsson & Asplund 2000). Other POPs like PCBs and PBDEs have also been used as flame retardants in cables and cable sheaths.

The major use of PCNs was during 1920s to 1960s and most of these cables from electrical equipment have already entered end of life and have either been disposed to landfills, treated in cable recycling or other end of life treatment and would therefore not require a specific inventory or management activity.

However cables used in construction of houses or other long term use containing PCNs might still exist.

Cables containing PCBs (used in the 1960s/1970s) and PBDEs (produced since the 1970s) are partly still in use. Today SCCPs are partly used as additives in cables. The use of CPs in cables and other plastic components in baking ovens has resulted in contamination of German baking ovens with SCCPs/MCCPs (Gallistl et al. 2018).

3.2.2 Production of cables in South Africa

South Africa has some production of cables. The cable manufacturers do not specify what chemicals they use as additives. One producer explicitly stated that he has flame retarded cables which might be POPs (SCCPs, DecaBDE) or other flame retardants.
Many cables are coated with PVC. For some cables, it is mentioned that they contain plasticiser but the type of plasticiser is not stated. For some PVC cables, the manufacturer guarantees "Lead Free". Some cables have proven standards according to DIN 72551 or ISO 6722 Class B but this also does not guarantee that they are POPs free.

Aberdare Cables (https://www.aberdare.co.za)
The cable manufacturer Aberdare cables has been in operation since the 1940s (more than 72 years). Therefore, they might have used PCNs, PCBs and SCCPs as additives in the past. They have three operation sites in South Africa. There is no information online what chemicals are used.

Walro Flex (https://walroflex.com/)
Walro Flex is the largest producer of automotive wire and battery cable within South Africa. According to the manufacturer, the outer material of the cabling is fully flame retarded, due to its proximity to highly flammable liquids, which could cause devastating damage to engines. There is no information online what chemicals are used.

Cabletronics (http://www.cabletronics.com/)
Cabletronics have been producing a range of cables in South Africa since the 1980s and additionally import different cable types. Therefore, the company has most likely not used PCNs and PCBs in the past but might have used or use SCCPs as plasticised. However, they acquired a company which produced cables before 1980s which might have used PCNs or PCBs in their production. The company's product portfolio also contains fire proof cables which might contain flame retardants like SCCPs or DecaBDE.

CABCON (http://cabcon.co.za/)
Cabcon Technologies (Pty) Ltd started in 2003 as a small distributer of basic cables in Benoni, but quickly grew into a significant manufacturing company with hundreds of local and specializnly 2003ed cables, connectors and accessories that are manufactured and distributed across the world. Since production started the company has not used PCBs or PCNs in production.
The company also produces PH30 as well as PH120 fire resistant cables which meet manufactures that fully comply with the requirements of standard SANS 10139 and the maximum survival time stated in section 4.1 of BS EN 50200 and BS 8434-2 test methods.
The company stated that "CAB-TECH FIRE" fire resistant cable is sheathed using a red non-toxic halogen free compound and that the halogen free compound produces low emissions of smoke and reduces propagation of fire along the cable; this compound complies with specification standards IEC 60092(SHF1) and SANS 1411-5 (Zerotox Applications). Therefore, these cables of Cabcon Technologies (Pty) Ltd most probably do not contain SCCPs, DecaBDE or other POPs.
For other producers, assessments of used additives need to be conducted.

3.2.3 Import of cables to South Africa

There are major importers of cables to South Africa. These include, e.g., Helukabel (http://www.helukabel.com/za/) with productions in Germany and China with more than 30000 products in stock. Other cable suppliers are, e.g., KC Automotive Cables cc, ARB Electrical Industrial Cable Suppliers Johannesburg, Anropa Cables (Pty) Ltd, Anzac Cables And Wire Cc, and Alvern Cables (Pty) Ltd.

3.2.4 Gap assessment and research need

Only a few of cable suppliers stated that they are halogen free. Therefore, several of these cable producers and cable manufacturers might use halogenated flame retardants possibly including SCCPs or another flame retardant, e.g. DecaBDE. Also some of these cables might contain unintentional PCNs and PCBs contained in CP additives.

Selected measurements of the cables are needed for Tier III inventory.

Therefore, within the inventory, information on cables containing PCNs, PCBs, PBDEs and SCCPs would be compiled. If data on PCN levels in the recycled cables are available, such information should also be noted in the inventory.

The information on the management of such cables should be assessed and evaluated in the inventory report as a basis for the establishment of environmentally sound management of cables and in respect to circular economy in the country.

What happens with waste cables in South Africa? Is there any recycling of cable sheaths?

3.3 SCCPs, PCNs and PCBs in PVC

PVC seems a major use of SCCPs additives. The use of SCCPs as secondary plasticizers in flexible polyvinyl chloride has been exempted, except for the use in toys and children's products where the use is not allowed.

SCCPs or CP mixtures containing SCCPs are used mainly as secondary plasticisers. The primary plasticisers are generally phthalates or phosphate esters (Houghton 1993). Primary plasticisers in PVC are used to increase the elongation properties and softness of the polymer. Secondary plasticisers, when used in combination with primary plasticisers, cause an enhancement of the plasticising effect, and so are also known as extenders.

Flexible PVC has many applications such as electrical cable sheething, in plumbing, conveyor belts, imitation leather, flooring, signage, phonograph records, inflatable products or tubes for outdoor decoration bulbs.

For use in PVC, it is possible that pellets (masterbatch) containing SCCPs could be manufactured outside the country and then imported into the country for further processing to give the final product (UK EPA 2000).

3.3.1 Production of PVC in South Africa

South Africa has a local polyvinyl chloride (PVC) manufacturer – Sasol. The yearly production of PVC resin is around 144 000 tonnes for 2010. Sasol entered PVC manufacturing only in the 1990s when they established the company Polifin together with AECI.

AECI has produced PVC before (since 1955) at Umbogintwini (in conjunction with chlorine production). The production of PVC and chlorine is associated with the unintentional production and release of PCDD/Fs and other UPOPs including PCNs (see Chapter 6).

The PVC raisin can be converted in a wide array of products. The most relevant products in respect to SCCP use are soft PVC products (see below).

3.3.2 Use of PVC in the manufacturing of products

PVC resin is converted to a wide array of products. Since South Africa has a large PVC production, the further use of PVC resins to manufacture products takes place in South Africa in different factories. Soft PVC products may contain up to 50% of plasticizer (and up to 15% secondary plasticizer such as SCCPs) and are manufactured e.g. by Continental Compounders (https://www.compounders.co.za/), Encomix (https://www.encomixsa.com/), Maizey Plastic https://www.maizey.co.za/), Macbean Beier Plastics (https://www.neucoat.co.za/), Seldenrod (https://www.seldenrod.co.za/), Trioplastics (https://www.plastixportal.co.za/), and Weldyne (https://www.weldyne.co.za/).
In this preliminary inventory the type of additives in use were not assessed for these producers.

3.3.3 Import of PVC

Large and increasing amounts of PVC are imported to South Africa over time (Figure 3). The assessment of the import volumes of plasticized PVC which possibly could contain SCCPs as secondary plasticizer were compiled from import data by selected HS codes (

Table ***5***). This includes e.g. plates, sheets, film, foil and strip plasticised with >6% plasticizer; plasticized PVC in primary forms. From 2000 to 2017 the highest import volumes were floor, wall or ceiling coverings of PVC in rolls or in the form of tiles (total 688,000 tonnes). The amount of plates, sheets, film, foil and strip with high content of plasticiser (≥6%; HS 392043) imported between 2000 to 2017 were 39200 tonnes and therefore less compared to the same products with <6% plasticizer (125000 tonnes; HS392049) (Figure 4). However, in recent year (2017) the plates, sheets, film, foil and strip with high content of plasticizer (≥6%; HS 392043) were imported at slightly higher amounts (4840 tonnes/year) compared to the same materials with <6% plasticizer (4755 tonnes; HS392049).

Currently, it is unknown what share of the individual PVC formulations and products contain SCCPs. This need to be assessed by monitoring studies and the necessary capacity is currently established. The challenge will be in future on how to separate PVC containing SCCPs (and other problematic additives like lead, cadmium and softeners which are already restricted under some regulatory frames (e.g. EU has restricted DEHP and three other phthalates in consumer products)[4].

PVC wastes, parings and scrap (HS391530) which can potentially be contaminated with SCCPs was imported to South Africa at very low volumes of total 2 tonnes for 2000 to 2017 (Figure 4) and 300 kg for 2017 (Figure 5).

[4] The European Commission has adopted a Decision to amend the REACH Regulation and restrict the use of the phthalates, Di(2-ethylhexyl) phthalate (DEHP), Butyl benzyl phthalate (BBP), Dibutyl phthalate (DBP) and Diisobutyl phthalate (DIBP) in consumer products on the EU market. The restriction, will take effect from 8 July 2020.

Table 5. HS codes of PVC imported to South Africa containing plasticizer and possibly SCCPs

HS Codes	Description
(3904)	(Polymers of vinyl chloride or of other halogenated olefins, in primary forms)
390422	Vinyl chloride, other halogenated olefin polymers; plasticised poly(vinyl chloride), in primary forms, mixed with other substances
391530	Vinyl chloride polymers; waste, parings and scrap
391810	Floor, wall or ceiling coverings; of polymers of vinyl chloride, whether or not self-adhesive, in rolls or in the form of tiles
392043	Plastics; polymers of vinyl chloride, containing by weight not less than 6% of plasticisers; plates, sheets, film, foil and strip (not self-adhesive), non-cellular and not reinforced, laminated, supported or similarly combined with other materials
392049	Plastics; polymers of vinyl chloride, containing by weight, less than 6% of plasticisers; plates, sheets, film, foil and strip (not self-adhesive), non-cellular and not reinforced, laminated, supported or similarly combined with other materials
392112	Plastics; plates, sheets, film, foil and strip, of polymers of vinyl chloride, cellular

Source: https://www.foreign-trade.com/reference/hscode.htm?code=3904

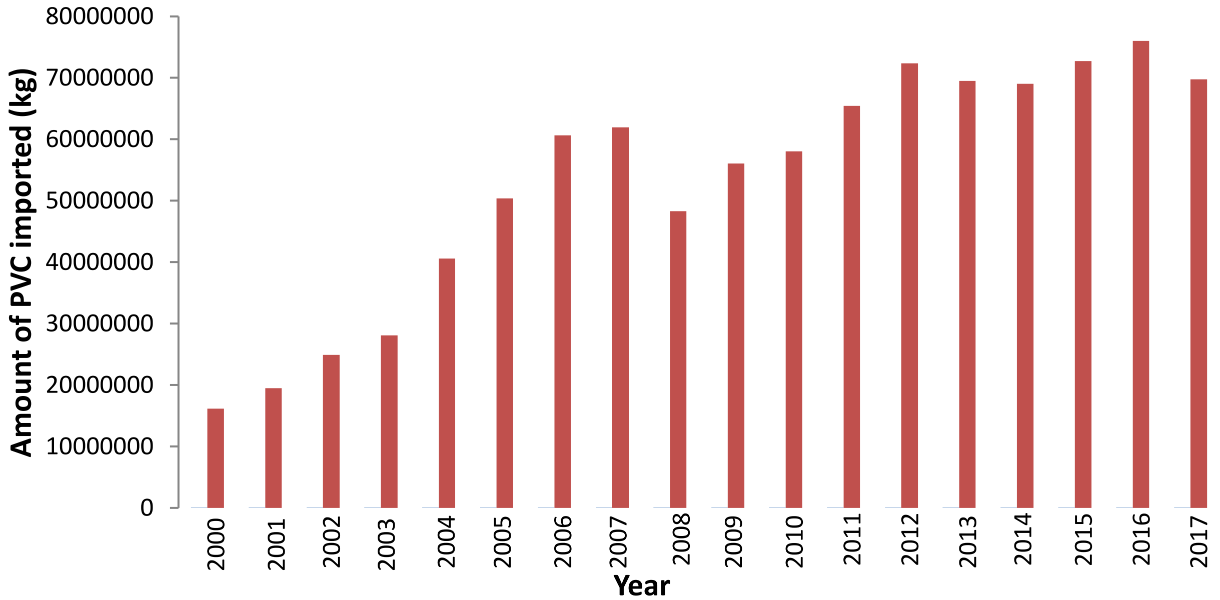

Figure 3. Time trends of selected PVC import in South Africa containing plasticizer which partly might contain SCCPs (2000-2017)

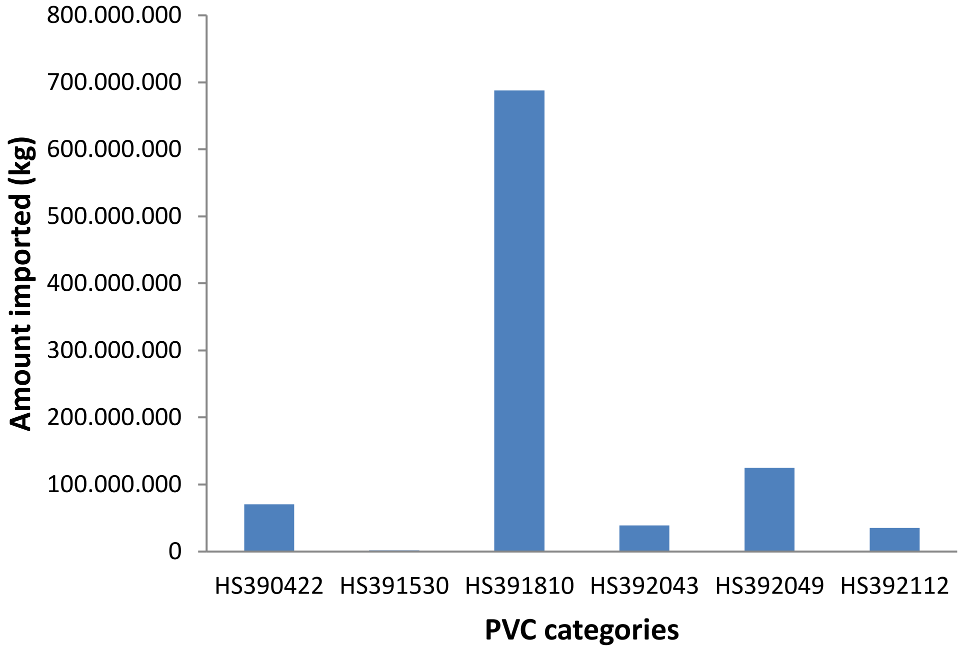

Figure 4. Amount of PVC imported to South Africa (2000-2017) in PVC-categories which contain additives and possibly containing to some extent SCCPs

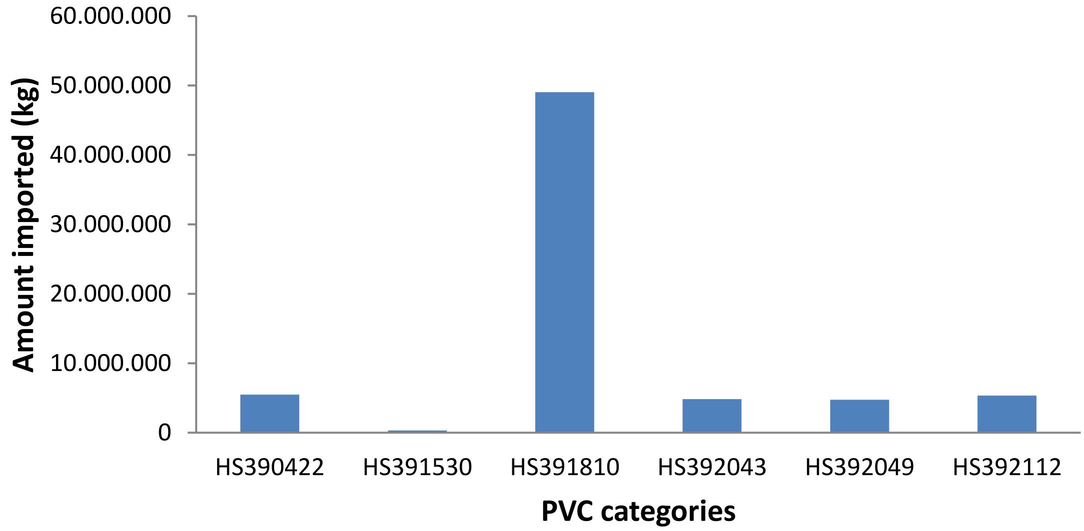

Figure 5. Amount of PVC imported to South Africa (2017) in PVC-categories which contain additives and possibly containing SCCPs to some extent

3.3.4 Gap assessment and research need

Many (soft) PVC products have been found to contain SCCPs as additives and the use of SCCPs in PVC is still exempted under the Stockholm Convention. Therefore, several of produced or imported PVC products might contain SCCPs or CPs contaminated with SCCPs. Also some of these PVC products might contain PCNs and PCBs as unintentionally byproducts in CP additives. Selected measurements of PVC products are needed for a reasonable Tier III inventory.

Also the assessment of the recycling situation and the (possible) levels of POPs and other restricted additives in PVC products going into recycling should be assessed and evaluated in respect to circular economy.

3.4 PCNs and SCCPs in rubber products

3.4.1 Background

PCNs have been used in chloroprene rubber until around 2000 (Yamashita et al. 2003; Yamamoto et al. 2018). Such chloroprene rubber has been used in rubber belts, rubber belts for printers and shock absorbing materials. For other rubber types no detailed information on PCN or PCB use is available. Since the production/use stopped for PCNs around 2000 and for PCBs ca. 1990[5], no intentional addition of PCNs and PCBs in rubber might have taken place in the last 20 years. Therefore, PCNs and PCB containing rubber are not in current imports or sales but rather mainly in end of life and possibly in recycling of rubber.

SCCPs have also been used and are still used in a wide range of rubber production as flame retardants and/or plasticizers. In the Stockholm Convention frame SCCPs are exempted as additives in the production of transmission belts in the natural and synthetic rubber industry. Also spare parts of rubber conveyor belts in the mining and forestry industries. The Stockholm inventory guidance recommends an overall assessment of the use of SCCPs and other CPs containing >1% SCCPs in rubber production since companies might have difficulties to distinguish exempted and non-exempted uses in the rubber industry.

The use of SCCPs and other flame retardants in rubber applications depends on the individual uses and the related safety and in particular flammability standards. Applications where rubber compounds might be flame retarded with different SCCP content (Table 6) include e.g.:

- Rubber conveyor belts
- Rubber transmission belts
- Rubber in sealants in housing

Rubber applications in the transport sector (cars, busses, trains, airplanes)

- Rubber cables
- Industrial rubber rollers

SCCPs have also been used in rubber hose, industrial sheeting, and shoe soles with different SCCP content (Table 6) (BRMA 2001).

For the inventory, the producers of the different types of rubber and rubber products and applications would be contacted to gather the information on the current and former use of SCCPs in the respective products.

Table 6. Rubber applications possibly containing SCCPs or other CPs with >1% SCCPs and related additive content used (BRMA 2001)

Coating type possibly containing SCCP (or other plasticizer)	Content (% wt)
Conveyor belting	10 – 16.8%
Rubber cable cover	3.8%
Rubber hose	6.2%
Industrial roller coverings	up to 20%
Pipe seals	4%

[5] PCBs are still produced in North Vietnam. However there is likely no export of PCBs or PCB containing products.

Coating type possibly containing SCCP (or other plasticizer)	Content (% wt)
Fire resistant rubber products	10%
Shoe soles	6.5%
Industrial sheeting	13%

Please note: For rubber tyres normally no flame retardants are added and therefore tyre production is not considered as a use of SCCPs. However, CPs (including SCCPs) were detected in a first assessment in all car tyre granulates in Netherlands between 10 and 75 mg/kg levels. The SCCP levels were in all samples <50 ppm (Brandsma et al. 2019).

3.4.2 Overall importation of rubber containing additives into South Africa

A wide range of rubber types and products potentially containing plasticizers including SCCPs are imported to South Africa (Table 7). In addition to conveyor or transmission belts or belting (HS4010), rubber tubes, pipes and hoses, of vulcanised rubber (other than hard rubber) (HS4009), articles of apparel and clothing accessories (including gloves, mittens and mitts), for all purposes, of vulcanised rubber (HS4015) and other articles of vulcanised rubber other than hard rubber (HS4016) were imported between 2000 to 2017 in volumes of 274000t, 146400 t, 76400 t and 184500 t respectively.

Conveyor or transmission belts or belting (HS4010) which have the largest import to South Africa from all rubber products (Figure 7 and Figure 8) which might contain SCCPs or other flame retardants, are discussed below in Chapter 3.4.3.

Table 7. HS codes categories of selected rubber which possibly could contain SCCPs

HS Code	Description
400239	Rubber; synthetic, halo-isobutene-isoprene rubber (CIIR or BIIR), in primary forms or in plates, sheets or strip
400241	Rubber; synthetic, chloroprene (chlorobutadiene) rubber (CR), latex, in primary forms or in plates, sheets or strip
400249	Rubber; synthetic, chloroprene (chlorobutadiene) rubber (CR), (other than latex), in primary forms or in plates, sheets or strip
400300	Rubber; reclaimed rubber, in primary forms or in plates, sheets or strip
400400	Rubber; waste, parings and scrap of rubber (other than hard rubber) and powders and granules obtained therefrom
4007	Vulcanised rubber thread and cord
4008	Plates, sheets, strip, rods and profile shapes, of vulcanised rubber other than hard rubber
4009	Tubes, pipes and hoses, of vulcanised rubber (other than hard rubber), with or without their fittings (e.g. joints, elbows, flanges)
4010	Conveyor or transmission belts or belting, of vulcanised rubber
4015	Articles of apparel and clothing accessories (including gloves, mittens and mitts), for all purposes, of vulcanised rubber other than hard rubber
4016	Articles of vulcanised rubber other than hard rubber

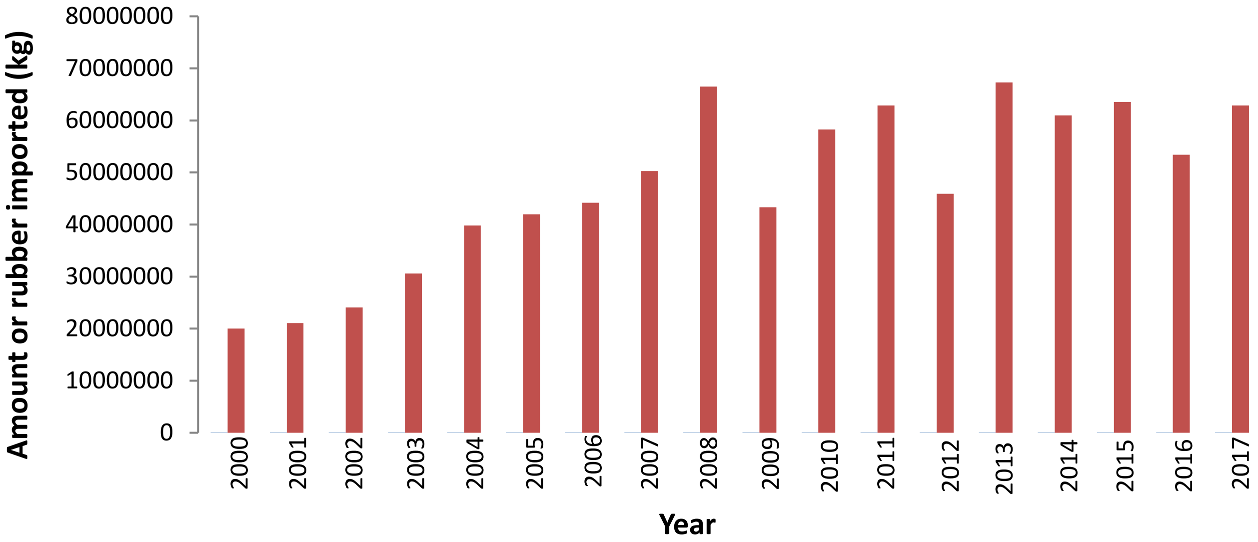

Figure 6. Trends in import of rubber in South Africa (2000-2017)

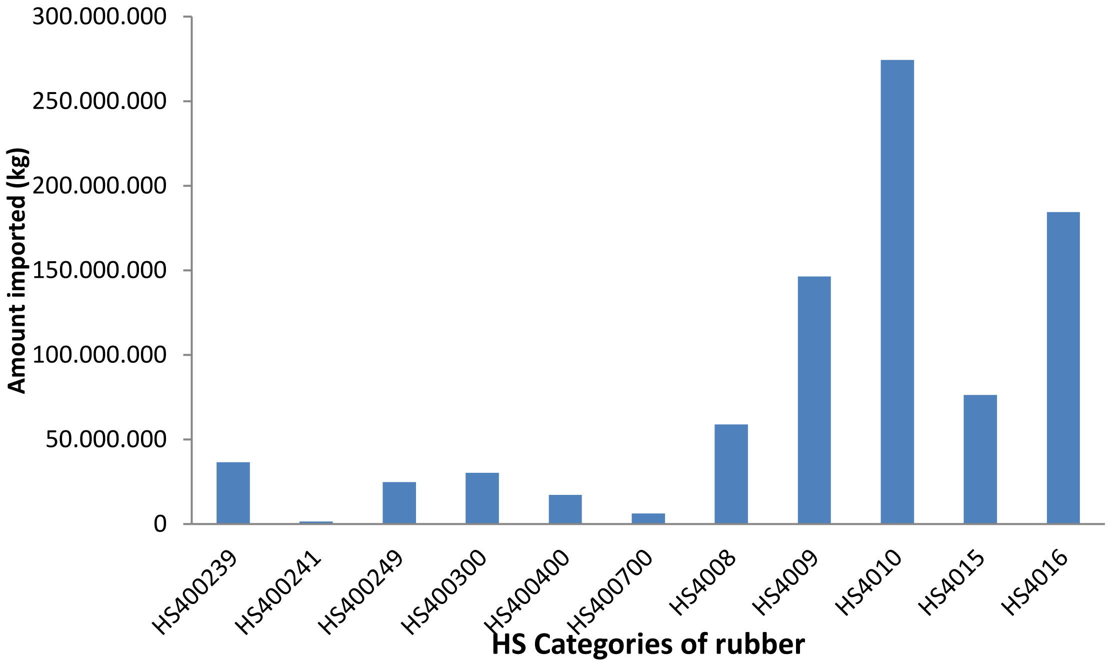

Figure 7. Amount of rubber potentially containing plasticizers, imported under different HS categories into South Africa in the period from 2000 to 2017

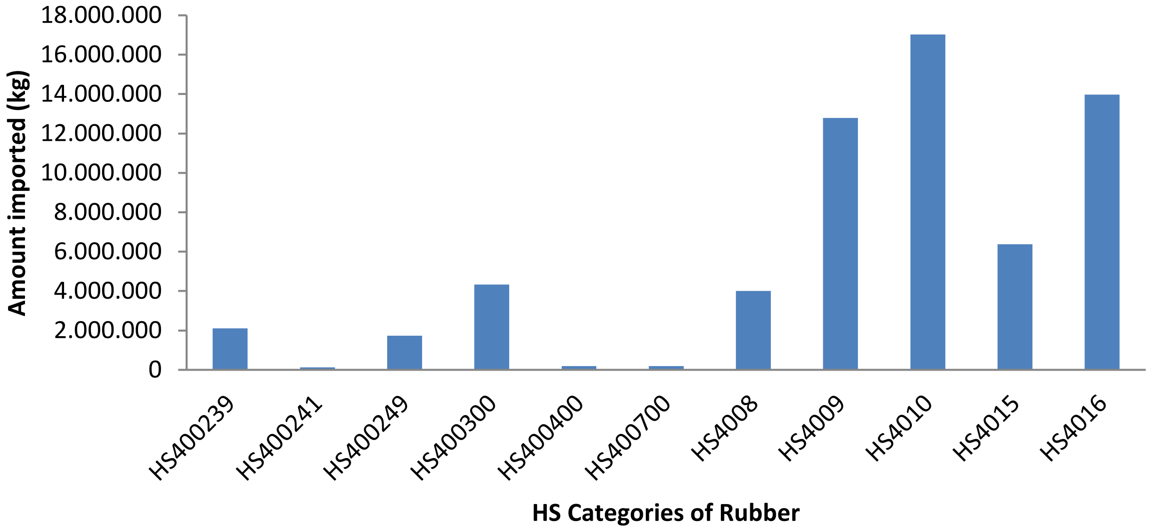

Figure 8. Amount of rubber potentially containing plasticizers, imported recently (2017) under different HS categories into South Africa

3.4.3 Conveyor and transmission belts

3.4.3.1 Background

Conveyor belts are a major rubber application. According to the Conveyor Belt Guide (2018), rubbers such as natural rubber (NR), styrene and butadiene rubber (SBR), polybutadiene rubber (BR), acrylonitrile and butadiene rubber (NBR), butadiene or isoprene rubber (IIR) and ethylene propylene diene monomer (EPDM) rubber have very poor flame resistance (Conveyor Belt Guide, 2018). Therefore, these rubber types require the addition of flame retardants for uses where flammability standards exist such as for conveyor belts (ISO 340:2013).

On the other hand, chlorobutadiene rubber (e.g. chloroprene, also known as neoprene or CR) and PVC have inherent flame resistance. However, it is known that SCCPs are used as additives in PVC as secondary plasticiser (see Chapter 3.3). Also chloroprene rubber may be used for mining conveyor belt compounding alongside chlorinated paraffins for both the cover compound and the skim compound (Dick 2001). Chlorinated paraffin may be used in 15% per weight in chloroprene cover and 30% by weight in a skim coat (Dick 2001). Therefore, SCCPs or other CPs containing 1% SCCPs might be in use for the production of all major types of rubbers used in rubber belts and would be assessed for SCCP use (UNEP 2019b,c).

3.4.3.2 Import of rubber belts into South Africa.

In total 274,000 tonnes of rubber belts have been imported into South Africa between 2000 and 2017 under HS code 4010 (Figure 7) with a recent import of 17000 tonnes in 2017 (Figure 8). The largest amount of these rubber belts are still in operation considering that a rubber belt is normally used for 10 years and longer. Considering a plasticizer/flame retardant content of 10 to 16.8% (Table 6) a total amount of 27400 to 46032 tonnes of plasticizer/flame retardants are contained in rubber belts. The share of SCCPs in this volume is currently not known. As rubber belts are a large use category, monitoring of rubber belts is needed to understand the SCCP amount currently imported, in use, and in end of life. Such monitoring should also try to reveal if SCCP use has decreased over time or if the

SCCP use depends on the region from where the rubber belt is imported (for such a study a similar structured approach as taken by the monitoring of PBDE in TVs and computers in Nigeria could be taken (Sindiku et al. 2015). The time trend of conveyor and transmission belts (HS code 4010) imported into South Africa is shown in Figure 9.

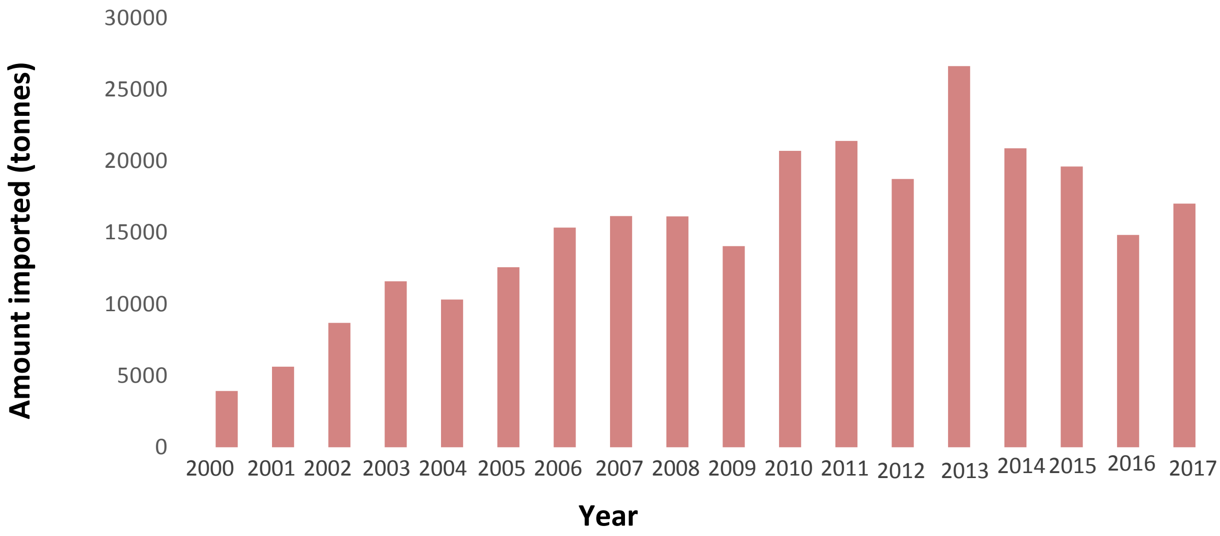

Figure 9. Time trend of imported conveyor and transmission belts to South Africa (HS code 4010)

3.4.3.3 Production of rubber belts in South Africa

South Africa also has companies that produce rubber belts. These include, e.g.,

- Dunlop Industrial Africa which has been manufacturing high quality conveyor belting in South Africa for the world since 1929 (https://www.dunlopindustrial.co.za/)
- Chiorino South Africa which is an affiliated company of the CHIORINO GROUP with headquarters in Biella, Italy seems to produce and import rubber belts. (https://www.chiorino.com/en/home-filiali.php?id=16).

The chemicals used in production were not identified in this preliminary assessment.

3.4.4 Rubber consumer products in current use potentially containing PCNs and SCCPs

Since PCNs have been phased out for 20 years most rubber products have already been disposed in the last years which for South Africa means mainly landfills and dump sites (see below Section 7.2.4).

Since SCCPs have been produced and used in the last 50 years, there is likely a large stock of rubber products containing SCCPs. No monitoring of SCCPs or PCNs have been conducted in South Africa yet and only initial monitoring in Europe and Japan has been conducted where some rubber parts in toys contained SCCPs at levels of 8,300 mg/kg and 17,000 mg/kg (see Annex 1). These values are above the European regulation limit for SCCPs (1500 mg/kg). Surprisingly, granulates from car tyres contained CPs at concentrations of 10 to 75 mg/kg with SCCPs levels below 50 mg/kg with an estimated total release of 2 to 89 tonnes of CPs to the environment in the Netherlands alone (Brandsma et al. 2019).

3.4.5 Recycling of rubber products and fate of PCNs and SCCPs in waste rubber

While there are recycling activities for rubber tyres in South Africa, no recycling of other rubber products such as rubber belts have been discovered in this preliminary assessment. Considering that the South African industry is planning to move to a (more) circular economy (Mativeng et al. 2017) POPs and other hazardous chemicals in large waste categories like rubber or PVC need to be known in order to phase them out from recycling and substitute them in the products.

3.4.6 Gap assessment and research need

Rubber products have used and are still using SCCPs as additives to some extent and the use has been exempted under the Stockholm Convention. Therefore, several of produced or imported rubber products might contain SCCPs or CPs contaminated with SCCPs. Also some of these rubber products might contain PCNs and PCBs as unintentionally byproducts in CP additives. Selected measurements of rubber products are needed for a reasonable Tier III inventory.
Also the assessment of recycling situation and the (possible) level of waste rubber products going into recycling should be assessed and evaluated in respect to circular economy.

3.5 PCNs, SCCPs and PCBs in paints and coatings

3.5.1 Background

PCNs have been used in lacquers and underwater paints and as raw materials for dyes (IPCS 2001; Jacobsson & Asplund 2000). Bayer produced paints containing PCNs until the beginning of the 1980s (Potrykus et al. 2015). PCBs have been used in such paints which were a major open application of PCBs until the 1970s and possibly early 1980s (Jartun et al. 2009; Markowitz et al. 2018; Wagner et al. 2014).
Since PCNs, SCCPs and PCBs have similar open applications in paints and painted constructions and equipment these POPs can be addressed in a common inventory of such applications.
PCNs, PCBs and SCCPs have been used in paints and coatings as corrosion protection for metal constructions such as bridges, towers, ships, pressure pipes, water sluices, electricity poles, transformers, tanks (outdoor and indoor) and machinery (Eklund & Eklund 2014; ELSA 2016;; Johnsen & Engoy 1999; PCB Elimination Network 2014; USEPA 2000; USEPA 2013; Wagner et al. 2014). For PCBs it has been described that such additives were mainly used in chloroprene paints and chlorinated rubber lacquers as well as in PVC copolymers (BUWAL 2000). Concentrations ranged from 5 to 35% (BUWAL 2000). For Aroclor-containing paints, a concentration of up to 10% Aroclor 1254 has been reported, which, after drying, resulted in a PCB concentration of up to 25% (Griggs & Bellrichard 2011). Chlorinated rubber paints containing PCNs or PCBs were also used in underwater paints and lacquers for concrete and brick. They were used as undercoat and as top coat/covering colour (BUWAL 2000). Monitoring data are mainly available for PCBs (Weber et al. 2018a). For Switzerland it is estimated that at least 20% of swimming pools contain PCBs while the share of PCNs has not been estimated (Knechtenhofer 2009) and currently an inventory is developed for all public pools (AGIR 2013). The use of paints containing PCBs in silos for animal feed has also been reported which resulted in the contamination of feed and milk (de Alencastro et al. 1984; Justitia 2016).
While contamination of cows with PCNs has also been documented (US Ministry of Agriculture 1954) major sources were lubricating oil and grease. It is unknown if PCN containing paints have been used for purposes which are exposure sensitive for human exposure.

PCB paints have also been used as flame retardants for wood panels for room ceilings ("Wilhelmi" Panels), for road marking, paints on concrete, brick and in screed (Jartun et al. 2009; Markowitz and Rosner 2018); Weber et al. 2018a). It is unknown if PCN paints have been used for these purposes but PCNs have also been used for wood treatment. Furthermore, PCNs were unintentional POPs in PCBs and related products.

SCCPs (and MCCPs) have substituted PCNs and PCBs in such application (Petersen 2012). SCCPs are used in waterproofing or intumescent paints and coatings as plasticizer or flame retardant to improve resistance to water and chemicals and reduce flammability (ECB 2008; USEPA 2009, UNEP 2015). The paints are used mainly in industrial/specialist applications such as marine primer paints and fire retardant paints (ECB 2008; RPA 2010), road marking paints, anti-corrosive coatings for metal surfaces, swimming pool coatings, and decorative paints for internal and external surfaces (RPA 2010).

3.5.2 Fireproof paints and coatings producers/sales in South Africa

There are several fire resistant paint specialists in South Africa with expertise for different substrate (steel, wood and concrete).

The South African manufacturers include Mandoval Vermiculite Innovations (Durban), Timberlife (Pretoria) fire retardant paint for wood, My Big Nano (Johannesburg) and Micon (Johannesburg). Major South African suppliers of fireproof paint often use internationally recognised products from manufacturers such as AkzoNobel, Sika, and Jotun.

Today these coatings/paints do not contain intentional added PCNs/PCBs but might contain SCCPs and at lower levels unintentional PCBs and PCNs.

Some fire resistant paint/coating companies and related specialization are shown in Table 8.

Table 8. Fire resistant paint/coating companies and related specialization (https://www.coating.co.za/fireproof-coating-za/)

Fire resistant coating company	Address (ZA)	Specialisation
Bidvest TMS Industrial Services	Unit 11A Growthpoint Business Park, 2 Tonetti Street, Halfway House, Midrand, Johannesburg, 1685	Industrial fireproof coating for steel
Curvent International	75 North Rand Road, Hughes, Boksburg, Gauteng, South Africa	Insulation and fireproofing cables and fire and smoke ventilation.
Royal Coat Africa	28 4th Avenue South, Fountainbleau, Randburg, Johannesburg.	Industrial intumescent paint and mastic fire resistant coatings
Fireco	Century Boulevard, 1st Floor, East Block, Century City, 7441	Fire protective design and application of fire resistant coatings

3.5.3 Waterproof paints and coatings producers/sales in South Africa

Water proofing paints and coatings are produced and sold in South Africa from various companies. This includes e.g. Duram (https://www.duram.co.za/), NuSeal (https://nusealwaterproofing.co.za/),

WeatherPrufe Paints (https://www.weatherprufe.co.za/), Wondercoat (http://www.wondercoatpaints.co.za/).
Today these coatings/paints do not contain intentional added PCNs/PCBs but might contain SCCPs and at lower levels unintentional PCBs and PCNs.

3.5.4 PCNs, SCCPs, PCBs in paints in buildings

Fire retardant and water proofing paints and other paints containing PCBs or PCNs have been used until the 1970s and 1980s, respectively (UNEP 2017a, 2019a). Therefore, only buildings constructed before 1980 and 1990 might contain PCBs or PCNs, respectively. SCCPs might be used in paints until today and are exempted.

3.5.5 PCNs, SCCPs, PCBs in paints of swimming pools, dams and other water reservoirs

Waterproofing paints/coatings have been and are used for swimming pools, dams, other water reservoirs and other applications. Only painted objects built before the 1980s might contain PCB or PCN containing paints. Some major dams built in the 1950s to 1980s are compiled in the section on PCB sealants and might contain also to some extent PCB/PCN containing paints (see 3.6.2 below). SCCP or other CP containing paints/coatings have substituted PCB/PCN paints/coatings in these applications and are used until today. Therefore, recently built painted swimming pools or dams or other painted objects having used water proofing paints/coatings might contain SCCPs as plasticizer.

3.5.6 PCNs, SCCPs, PCBs in ship paints and other metal construction

3.5.6.1 Background

PCNs and PCBs have been used in paints and coatings as corrosion protection for metal constructions such as bridges, towers, ships, pressure pipes, water sluices, electricity poles, transformers, tanks (outdoor and indoor) and machinery (Eklund & Eklund 2014; ELSA 2016; Johnsen & Engoy 1999; PCB Elimination Network 2014; USEPA 2000; USEPA 2013; Weber et al 2018a; Wagner et al. 2014). For PCBs it has been described that such additives were mainly used in chloroprene/chlorinated rubber paints and lacquers as well as in PVC copolymers (BUWAL 2000). Concentrations ranged from 5 to 35% (BUWAL 2000). For Aroclor-containing paints, a concentration of up to 10% Aroclor 1254 has been reported, which, after drying, resulted in a PCB concentration of up to 25% (Griggs & Bellrichard 2011).

3.5.6.2 PCNs, SCCPs, PCBs in ship paints

For some applications with long-term use like painted ships or bridges (see Brinkmann and Reymer 1976) it is possible that a certain proportion of PCNs is still in products built decades ago.
There are locations in South Africa where ships are repainted (http://www.dormac.net/locations/; https://www.gbaships.org/de/latest-news-item/r49487).
At these areas waste might be generated from removal/sand blasting of paints for repainting ships and need to be assessed.

3.5.6.3 PCNs, SCCPs, PCBs in paints of metal structures (e.g. bridges; towers; pylons)

Metal bridges, towers and metal pylons (e.g. transmission pylons) have long lifetime of often more than 40 years. Therefore, paints containing PCBs or PCNs from before 1980s might still be present at such constructions in South Africa. From recent cases it is known that removal of such paints can result in larger environmental release and contamination. (Jartun et al. 2009; ELSA 2016)

3.5.7 Gap assessment and research need

Paints and coatings have used and are still using SCCPs as additives to some extent and the use has been exempted under the Stockholm Convention. Therefore, several of produced or imported paint/coating products might contain SCCPs or CPs contaminated with SCCPs. Paints and coatings produced before the1980s might contain PCNs/PCBs. Also some of these paints/coatings products might contain PCNs and PCBs as unintentionally byproducts in CP additives. Selected measurements of current used paints/coating products and historically painted/coated objects are needed for a reasonable Tier III inventory.
Also the assessment of the recycling situation and the (possible) contamination level of waste rubber products going into recycling should be assessed and evaluated in respect to circular economy.

3.6 PCNs, SCCPs and PCBs in sealants/caulks and putty

3.6.1 Background

The use of PCNs in sealants and putty has been reported until around 2000 (Yamashita et al. 2003; UNEP 2013). For PCBs, sealants/caulks and putty in buildings and other constructions have been major open applications (Weber et al. 2018a; Wagner et al. 2014) while for PCNs those applications were minor. For PCBs, the uses were mainly from 1950s to 1970s or 1980s depending on the regulations in countries or regions. SCCPs (and MCCPs) are still used today for these applications and have received exemption for adhesives which cover sealants (Petersen 2012; UNEP 2017b). PCNs seem to have been used until about 2000 in East Asia (Yamashita et al. 2003). The buildings with a large amount of sealants were those with (prefabricated) concrete where sealants were used as joints. Typical sealants containing PCBs were polysulfide sealants (e.g. Thiokol). Due to the similar properties, these sealants may also contain PCNs or SCCPs. Other sealants that can contain PCBs, PCNs or SCCP are polyurethane, acrylic and butyl sealants. PCBs, PCNs and SCCPs have not been used in modern silicone rubber sealants.
Sealants containing PCBs or PCNs have also been used in putty for windows. Sealants in buildings can contain 5 to 30% of PCBs (Priha et al. 2005).
Due to the long lifetime of sealants in buildings of 30 to 60 years and longer, a considerable share of these sealants may still be in use.

3.6.2 Construction in South Africa with potential use of POPs containing sealants

South Africa had several major constructions in the 1950s to 70s in the time were PCBs and PCNs were used as additives in sealants. This includes the construction of dams which for Europe has been reported to contain PCBs in sealants and paints: Kougha Dam (1957-1969), the Gariep Dam (1971 originally named the Hendrik Verwoerd Dam), Sterkfontein Dam Reservoir (construction start 1969 and commissioned 1977), Vanderkloof Dam (1973-1977) and Kilburn Dam (1970s opened 1981)
Also dams and hydropower stations were constructed in the 1980s and 1990s (e.g. Colley Wobbles Power Station is a hydroelectric power facility; Bethlehem Hydro). These do likely not contain PCNs or PCBs but might contain SCCPs in sealants and paints.

Also large (prefabricated) concrete buildings were constructed in South Africa. Experience in Europe and US has shown. that university and school buildings built in the 1960s and 1970s can be affected with PCBs. This might concern: University of KwaZulu Natal (1960), Zululand University (1960), Nelson Mandela Metropolitan University (1964), University of Johannesburg (1966), Port Elisabeth Technikon (1967) Vaal University of Technology (1967);, Tshwane University of Technology (1967s), Cape Peninsula University of Technology (1967), Durban University of Technology (1967), ML Sultan Technikon (1969)[6], Peninsula Technikon (1972)[6] Sefako University of Medical Health Medunsa (1976), Walter Sisulu University (1977), Mangosuthu University of Technology (1979) (Cooper and Subotsky 2001).
These buildings might contain sealants with PCBs or PCNs but also SCCPs that have been produced this time.
Even more constructions have been built from 1990 to 2010 including 2 761 schools; more than 1 500 healthcare facilities; eighteen new hospitals. For these buildings constructed since 1990s no PCBs or PCNs have been used in sealants however SCCPs might have been used.

3.6.3 Monitoring of sealants in construction in South Africa

Monitoring of sealants in South Africa can assist in confirming the extent of use in the country since there are many sealants which do not contain POPs. Therefore, a first screening of sealants with XRF has started at Tshwane University. Already some chlorine positive sealants have been discovered with XRF screening and will be analysed for PCBs, PCNs and SCCPs after development of analysis.
The screening will be extended to other constructions.
The screening can also include the demolition of buildings where sealants could be sampled/screened.

3.6.4 Survey in companies producing or importing sealants and adhesives

An initial screening of companies producing or importing sealants has been conducted.
South Africa has a National Adhesives and Sealant Manufacturing Association (N.A.S.M.A.; founded in 1975) to promote & develop the adhesive & sealant industry in South Africa. To date, the association consist of members who are responsible for 75% of all adhesives sold in South Africa. Sealant providers include e.g. Adtec, Alcolin, BASF, Builders, Den Braven Sealants, Henkel, Pattex, Permoseal, Qualichem-Genkem.
The overall production portfolio of these companies covers all sealant types which possibly contain SCCPs (or formerly contained PCBs/PCNs) such as polysulphide sealants, acrylic sealants, butyl sealants, or polyurethane sealants.

3.6.5 Gap assessment and research need

Sealants/adhesives have used and are still using SCCPs as additives to some extent and the use has been exempted under the Stockholm Convention. Therefore, several of produced or imported sealants/adhesives products might contain SCCPs or CPs contaminated with SCCPs.
Sealants/adhesives from before 1980 might contain PCNs or PCBs. Also some of the current used paints/coatings products might contain PCNs and PCBs as unintentionally byproducts in CP

[6] All part of CPUT now

additives. Selected measurements of current used sealants/adhesives products and historically sealants/adhesives in construction are needed for a reasonable Tier III inventory.
Also the assessment of the recycling situation and the (possible) contamination level of construction and demolition waste going into recycling should be assessed and evaluated in respect to circular economy.

3.7 PCNs, PCBs and SCCPs in metal working fluids, cutting oils and lubricants,

3.7.1 Background

A major use of SCCPs/MCCPs is in metal working fluids, cutting oils and lubricants. These uses have also received exemption (Table 3).
Also the use of SCCPs in lubricants has been exempted by the Stockholm Convention.
Therefore, SCCP is possibly used in this application in South Africa and need to be assessed and controlled or substituted.
Also PCBs and PCNs have been used as lubricants before 1970s. Since these are short time usesPCBs and PCNs are not in use in these applications at the present time.

3.7.2 Situation on metal working fluids in South Africa

Metalworking fluids are liquids, which are supplied to a manufacturing process of a metal in a way that allows for increased productivity based on lubricating and cooling effects (Brinksmeier et al. 2015). In various manufacturing processes, metalworking fluids (MWFs) are applied to ensure workpiece quality, to reduce tool wear, and to improve process productivity (Brinksmeier et al. 2015). MWFs play a significant role in manufacturing processes such as forming (Bay et al. 2010), cutting (Weinert et al. 2004), and grinding (Brinksmeier et al. 1999). By their lubricating and cooling properties, MWFs contribute to the avoidance of thermal damage of the workpiece material and reduce wear of the tool. Liquids which are included in the term MWFs have been classified based on different criteria. According to DIN 51385, MWFs are classified following their composition as oil-based or water-based MWFs. They can also be categorized according to the manufacturing process as cutting fluid, grinding oil or forming oil.
For oil-based fluids, the chlorinated paraffin content of the fluid ranges from about 5% wt. for light machining up to 70% wt. for heavy drawing processes (metal forming fluids) (BUA, 1992).
Chlorinated paraffins in general are used in a wide variety of cooling and lubricating fluids used during metal cutting, grinding and forming operations (Brinksmeier et al. 2015). Chlorinated paraffins are in particular used as extreme pressure additive in metal working.
Neat cutting oils find application in a variety of machining operations such as drilling, hobbing, turning, honing, and broaching as they help to enhance the surface finish along with increasing the tool life.

Metal working fluids are imported and used in South Africa. This includes companies like Chemical Solutions & Innovations (CSI) http://www.csi-africa.co.za/, Centlube https://www.centlube.co.za/metalworking/ Petromark (http://petromark.co.za/). Also the global lubricant players in South Africa including Mobile, Shell, Total and Sasol are likely providing metal working fluids. Therefore, the presence and use of SCCPs need to be assessed and possibly registered for a specific exemption at the Secretariat of the Stockholm Convention, or eliminated/substituted with better alternatives. A compilation of alternatives has been compiled in the (UNEP 2019f).

3.7.3 Situation on other lubricants in South Africa

Lubricants have been listed as exemptions in the Stockholm Convention (Table *3*). There are a wide range of lubricants uses. Lubricants are used in automotive (engine oils, transmission fluids and gear oils), industrial automotive (heavy duty vehicles; agricultural equipment, construction and other earth moving equipment; military) rail, ships, industrial machinery (e.g. machine bearings, centrifuge, rotary compressors, air compressors), power generation (e.g. wind power facilities; electric generators), drilling in oil and gas exploration, petroleum refinery, food & beverage (European Commission 2016; UNEP 2017b).

Initial assessment in Africa showed that chlorinated paraffins are even used in car oils. Therefore it is possible or likely that such car lubricant oil is also present on the South African market.

For industrial lubricants, global players in the lubricant market like Castrol, Mobile, Shell, Total and Sasol are present. These companies are likely aware of the listing of SCCPs in the Stockholm Convention and the related exemptions.
SCCPs are exempted e.g. for lubricants in wind power plants. Wind power parks started in South Africa since 2014 and are increasing (see for example https://en.wikipedia.org/wiki/List_of_wind_farms_in_South_Africa)
Lubricants used in this application might contain SCCPs or other CPs with SCCP content above 1%.

3.7.4 Gap assessment and research need

Lubricants and metal working fluids have used and are still using SCCPs as additives to some extent and the use has been exempted in the Stockholm Convention. Therefore, several of produced or imported lubricants or metal working fluids might contain SCCPs or CPs contaminated with SCCPs. Also some of the current used lubricants and metal working fluids might contain PCNs and PCBs as unintentionally byproducts in CP additives. Selected measurements of current used products are needed for a reasonable Tier III inventory.
Also the assessment of recycling situation and the (possible) level of SCCPs in waste oils going into recycling should be assessed and evaluated in respect to circular economy.

4 Consumer products on the market containing SCCPs, PCNs and PCBs

4.1 Background and available data from other countries

There are likely no current consumer products which contain intentionally added PCNs or PCBs since the last reported use for PCNs was around 2000 for neoprene FT rubber (Yamashita et al. 2003). The exemption for PCN production is only as intermediate for PFN production. Therefore no intentionally added PCN is expected in current consumer products. However there might be unintentional PCNs in some consumer products that are in use.

The new use of PCBs in open applications stopped in the early 1970s and in closed applications in the 1980s.[7] Therefore, e.g., capacitors in consumer products produced after 1990 should not contain PCBs or PCNs.
SCCPs are still used as additives in products such as PVC in toys, shoes construction materials and others (Kajiwara & Matsukami 2018) or rubber products (Brandsma et al. 2019; Takasuga et al. 2013).
Since the production of PCNs and PCBs has stopped more than 20 and 30 years ago, respectively, imported products are not expected to contain intentionally added PCNs or PCBs. However, unintentionally PCNs and PCBs might be contained in a range of products.

4.2 Import of SCCP containing consumer products

The type of products which have been found contaminated with SCCPs in the European and Japanese market (Annex 1; UNEP 2019b,c; Kajiwara & Matsukami 2018), include the following:

- Toys like plastic doll, toy doctor set (stethoscope), bouncy toy, stickers for children, rubber knife, toilet seat for children;
- Sports equipment: Beach ball, baseball glove, Fitness gloves, Abs trainer, Yoga mats, all-purpose mat,
- Artificial leather (PVC) wallet, handbags, mobile phone bag, brush case black, toiletry bag, wallet case for smartphones
- Cables in motor vehicle sidelight, USB-cord, digital thermometer cable, extension lead, kettle cable, game controller (cable), electric kettle (cord), lighting chain (cord)
- Baking ovens and kitchen blenders
- Other plastic/polymers like steering wheel cover, selfie stick, mobile phone case, rain cover for pushchair, cloche cover, garden equipment
- Further products (see Annex 1)

Such product categories and products are imported also to South Africa and are available in shops.

Gap: Currently there are no monitoring data from such consumer products from South Africa and entire Africa.

4.3 Export of products containing SCCPs, PCNs and PCBs

MCCP produced by NCP Chlorchem (Pty) Ltd. might be exported. According to the producer, there is no measurement of SCCP content in the MCCP lots currently.
Also rubber products or other products with added CPs might be exported.

[7] The only ongoing PCB production is in North Korea where products are not exported to Africa.

5 Assessment PCNs in closed applications (within PCB inventory activities)

The former use of PCNs in closed applications is largely identical to the use of PCBs (UNEP 2019a). PCBs were used in much higher volume than PCNs in closed applications such as transformers or capacitors. Therefore and because of only the recent llisting, PCNs have not been monitored in transformers and capacitors yet. On the other hand, there are a range of false positive measurements in PCB inventories from chlorine screening tests. Up to now these false positive transformer oils have not been further assessed for pollutants. With the listing of PCNs, such false positive need to be assessed for PCNs.

The monitoring of PCNs can be combined with the PCB analysis. By this, PCNs in closed applications could be addressed within or together with the inventory of PCBs in closed applications.

South Africa has started a GEF project to reduce and eliminate the use and releases of PCBs to the environment through development and implementation of a pilot project on Environmentally Sound Management (ESM), and the disposal of PCB-contaminated equipment and PCB-containing oils and wastes in South Africa (GEF Project ID 9576). This includes also a PCB inventory component. Furthermore, currently a GEF project on inventory and management of PCBs in SADC countries is ongoing (GEF Project ID5532) and samples are sent from SADC countries to the African Institute and a related laboratory for PCB analysis. In this process false positive samples are not being addressed after negative PCB analysis. Those samples should be analysed for PCNs to ensure that PCN containing equipment is managed in an environmentally sound manner.

5.1 Assessment of capacitors

A major use of PCNs was in capacitors, particularly in the impregnated paper, since the 1930s (Jacobsson and Asplund 2000). PCNs have been used in capacitors from 1930s until 1980s. PCNs have been used for a slightly longer period than PCBs which were mainly used in the 1940s to 1980s. However, the product and use volume of PCBs was about 10 times larger than that of PCNs. Therefore, PCNs in capacitors can be addressed within the inventory of PCBs in capacitors (UNEP 2019a). One challenge is that capacitors containing PCNs are likely not labelled.

Therefore, when old capacitors produced before 1980s give a false positive chlorine screening without detection of PCBs, additionally PCNs need to be assessed.

There is no indication that SCCPs are used in capacitors and therefore no specific assessment is needed.

5.2 Assessment of transformers and waste oils of transformers

The amount of PCNs in transformer oils was considerably smaller than of PCBs. Therefore, the amount of pure PCN transformers can be considered small and up to now there are no reported PCN transformers. However, PCNs exist at least as unintentional contaminants in all PCB transformer oils since commercial PCBs contained traces of PCNs (0.01–0.09% of PCB content; Falandysz 1998, Huang et al. 2015; Kannan et al. 2000, Yamashita et al. 2000).

The Basel Convention technical guidelines (UNEP 2017c) provides that it is generally possible to determine whether transformers contain PCBs, PCTs or PCNs by inspecting the equipment type designation on the name plates and the product labels or literature issued by the manufacturer, and by referring to the date of production of the equipment (UNEP 2017c). This is only true for originally PCB/PCN filled transformers but not for transformers which are cross contaminated with PCB oils by maintenance (UNEP 2019a).

The assessments of transformer oils containing PCBs are normally conducted using test kits which measure the total amount of chlorine of PCBs/content oil such as Clor-N-Oil or Dexsil test.[8] The chlorine detected could stem from PCBs or PCNs. PCN-containing condensers/transformers would also be identified within the monitoring of condensers or transformers for PCBs using GC-ECD. When the amount of chlorine detected by chlorine screening methods was considerably higher than the amount of PCBs detected by GC-MS, an additional analysis of PCNs should be performed (UNEP 2019a). When testing transformers and oils for POP contamination, masses for both PCBs and PCNs should be selected in the mass spectrometer.

Therefore, within those assessments, PCNs are also tested positive through the same mechanism as PCBs.

In the current and upcoming assessment of PCBs in transformers in South Africa and the SADC region, particular care will be taken of false positive samples from the screening test and analyse for PCNs.

It need to be stressed that even recently manufactured transformers without information on the plate could be contaminated with PCNs at levels above 10 mg/kg or PCBs of above 50 mg/kg through retro-filling or maintenance work. The insulating oils in electrical equipment potentially containing PCNs or PCBs should therefore be analysed for those chemicals.

To minimize monitoring cost, the mixture of false positive transformer oils could be analysed with respective appropriate detection limits. Also mixed waste oils from many transformers might be screened for an indication of the presence of PCNs.

There is no indication that SCCPs are used in capacitors and therefore no specific assessment is needed.

5.3 Further closed equipment assessed in the PCB inventory

Examinations of other suspected equipment that could contain PCBs (e.g. heat exchangers, circuit breakers, oil cisterns and pipe systems) should also be assessed for PCNs.

5.4 Assessment of hydraulic fluids from mining (PCNs, PCBs, SCCPs, HCBD)

PCNs, similar to PCBs, have been used in the hydraulic fluids, in particular in the mining sector at least until 1989 (Popp et al. 1997). During the development of inventory of PCBs in hydraulic oils in the mining sector and other sectors, PCNs (and PCTs or Ugilec)[9] could also be detected by the screening methods of PCBs based on the chlorine content.

The volume of hydraulic oils contaminated by PCNs (and PCBs) should be noted and distinguished in the inventory. The respective concentration of PCNs should also be recorded. The waste oil of the mining industry should be assessed for PCBs, PCNs and SCCPs.

[8] When using the density test for pre-screening of pure Askarel PCB transformers, pure PCN-containing transformers would also be tested positive since the density of PCNs is similar to that of PCBs (1.2 to 1.5 kg/l).

[9] The PCB substitute Ugilec is a mixture of tetrachlorobenzyltoluenes (TCBTs)

6 Initial assessment of unintentional PCNs

PCNs are unintentionally formed and released by thermal and other processes (Liu et al. 2014; UNEP 2019) and are subject to the requirements of Article 5 and Annex C to the Convention.
To assist Parties in the development of the inventories of the unintentionally produced POPs listed in Annex C to the Convention, the "Toolkit for Identification and Quantification of Releases of Dioxins, Furans and Other Unintentional POPs under Article 5 of the Stockholm Convention on Persistent Organic Pollutants (Toolkit)" has been developed (see http://toolkit.pops.int/).
PCNs are unintentionally formed together with other unintentional POPs such as PCDD/PCDF. and other unintentional POPs listed in Annex C, which can be minimized or eliminated by the same measures that are used to address PCDD/PCDF releases. When a comprehensive inventory of PCDD/PCDF is elaborated, it allows the identification of priority sources, setting of measures and development of action plans to minimize releases of all unintentional POPs. The Toolkit recommends, for practical reasons, that inventory activities be focused on PCDD/PCDF, as these substances are indicative of the presence of other unintentional POPs. They are considered to constitute a sufficient basis for identifying and prioritizing sources of all such substances as well as for devising applicable control measures for all Annex C POPs and for evaluating their efficacy.
In chapter 7 of the inventory guidance information on some major sources of unintentionally produced PCNs is compiled. In this initial assessment these sources have been considered and

- Identified which of these sources are likely present in South Africa
- Initial information has been compiled

6.1 Unintentional PCNs in industrial PCB mixtures

Unintentional PCNs are present in technical PCB mixtures at levels of about 40 to 1300 mg/kg (Huang et al. 2015; UNEP 2019a; Yamashita et al. 2000).
The inventory of PCBs has just started in South Africa and is ongoing in the SADC region. The content of unintentional PCNs in the PCB stockpiles can be calculated based on the PCB inventory data then.

6.2 Unintentional PCNs in the production of chlorinated paraffins

Chlorinated paraffins are produced by chlorination of C10–C30 n-alkanes from petroleum using molecular chlorine, either of the liquid paraffin or in a solvent, typically carbon tetrachloride. Depending upon the n-alkane feedstock, the reaction takes place at temperatures between 50 and 150 °C, at elevated pressures and/or in the presence of UV light (Kirk-Othmer 1991).
A first assessment of unintentional POPs in chlorinated paraffins revealed that chlorinated paraffins can contain high levels of PCBs and PCNs as well as PCDFs (Takasuga et al. 2012; UNEP 2013). The chlorination pattern of the PCBs and PCNs indicated that they had been formed by chlorination of biphenyl and naphthalene (Takasuga et al. 2012 b) and that they were likely present in the feedstock.
The total amount of unintentionally PCNs in the CPs was 40 mg/kg, slightly lower compared to the PCB concentration (Takasuga et al. 2012).
In South Africa - NCP Chlorchem (Pty) Ltd; (Address CNR Allendale & Chloor road, Chloorkop) - is producing and has produced chlorinated paraffins. According to the company they are not producing SCCPs and have never produced SCCPs but only MCCP (see below).

Considering the findings of PCNs and PCBs in chlorinated paraffins in Japan, selected lots of the MCCP products should be analysed for PCNs (and other unintentional POPs). The limit of detection needs to be below 10 ppm PCNs.

The factory producing chlorinated paraffins and factories using chlorinated paraffins should be approached for information including:

- The amount of chlorinated paraffins produced/used
- The amount of PCNs and other unintentional POPs in the chlorinated paraffin products;
- The amount of PCNs and other unintentional POPs in residues from chlorinated paraffin production;
- The current and historic amount of residues;
- The current management of these residues including destruction or disposal practices;
- The historic management practice of these residues including destruction and disposal practices;

For Tier III inventory CP products and residues from the respective producers should be analysed for PCNs and other unintentionally POPs.

6.3 Unintentional PCNs in the production of chlorine

High levels of PCNs have been formed during production of chlorine via chloralkali electrolysis formed together with PCDD/PCDFs and other unintentional POPs (Kannan et al. 1998; Weber et al. 2008). The highest levels of unintentional POPs were formed from chloralkali processes using graphite electrodes in particular when they use pitch-binders produced from coal tar containing high levels of polyaromatic hydrocarbons which were chlorinated during this process and served as precursors (Otto et al. 2006).

Most chloralkali electrolysis has stopped the use of graphite electrodes more than 20 years ago. Therefore, the unintentional POPs production in these industries has been reduced with significantly lower emission factors for PCDD/PCDF (UNEP 2013). It is not known to which extent such processes produce PCNs.

In South Africa at least two chloralkali productions were and are operating in Sasol company and in NCP Chlorchem (Pty) Ltd. The facilities have been in operation for more than 30 years. Sasol operates a chlorine, hydrochloric acid, sodium hydroxide and sodium hypochlorite production facility on the Sasol Midlands Site. Salt is conveyed to a dissolving tank where the salt is dissolved up to a specific brine concentration. After several purification steps, the brine solution is fed to the chloro-caustic cells where chlorine, hydrogen and aqueous sodium hydroxide is manufactured. Therefore, different levels of PCNs have been generated depending on the technology used. Since the chloralkali plants operate since 1959, also old technologies using graphite electrodes and possibly mercury cells have been used in the past. This history of technologies, the release vectors of the facilities and the locations where residues from chloralkali production have been disposed of needs to be gathered to conclude on further assessment needs.

Sasol also operates an incinerator plant. Therefore, today problematic residues might be destroyed to a large extent. For the assessment, the time since the incinerator has been in operation and the status of the incinerator as well as the location where residues from the incinerator are disposed

should be evaluated. Furthermore, the waste management and locations of landfills and disposal sites of the factory should be compiled.
For a Tier II inventory qualitative and quantitative information on the respective chloralkali sector should be gathered without doing measurement of POPs in the residues. The information could include:

- Amount of residues generated by chloralkali production per year;
- Available data on pollutants in the residues;
- Historic residues from chloralkali production with emphasize on sludge from graphite electrodes;
- Treatment of the residues including thermal treatment and disposal.

For a Tier III inventory measurements of residues could be analysed for PCNs and other unintentional POPs.

6.4 Unintentional PCNs produced in EDC/VCM production

Sasol is operating a large VCM/EDC production for the production of PVC.[10] Unintentional POPs are generated and released in the production of VCM/PVC (UNEP 2013). The process has also a chlorine production which produces unintentional POPs including PCNs.

6.5 Unintentional PCNs in thermal processes

PCNs are formed together with PCDD/PCDFs in thermal processes such as incineration or metal industries by the same mechanism (Imagawa & Lee 2001; Weber et al. 2001). The total concentration of PCNs in waste incineration are in the same order of magnitude as PCDD/PCDFs with somewhat higher levels of PCNs in the gas phase (Takasuga et al. 2004) and similar levels in fly ash (Imagawa et al.& Lee 2001).
Within the update of the South African NIP, the unintentional POPs inventory will be updated. In this frame also some additional assessments of unintentional PCNs can be made based on the activity rates compiled for PCDD/Fs and emission factors compiled for PCNs in the Stockholm Convention draft inventory guidance (Secretariat for the Stockholm Convention 2017).

6.6 Unintentional PCBs

Since PCBs are not a major topic of the current study but only in combination with PCNs and SCCPs in open application, the information on unintentional PCBs is only shortly mentioned here for completeness. This information can be integrated in the unintentional POPs inventories developed in South Africa for the NIP update.

6.6.1 Pigments and paints

A range of starting materials for the production of paints and coatings contain unintentional POPs, such as pigments or organochlorine solvents (Anezaki & Nakano 2014; UNEP 2013; Weber 2015). Some of these are major pigments frequently used e.g. in plastic. Therefore, some unintentional PCBs are likely imported to South Africa via import of certain pigments and paints and in products which contain such pigments/paints.

[10] https://www.sasol.com/about-sasol/strategic-business-units/chemical-business/base-chemicals/products

6.6.2 Chemical industrial processes

Unintentional PCBs are also formed in other processes of the organochlorine industries and chlorine production but are normally less relevant UPOP compared to PCDD/F. In residues of PVC production and chlorine production in South Arica also some unintentional PCBs are likely formed.

6.6.3 Thermal processes

PCBs are formed together with PCDD/PCDFs in thermal processes such as incineration or metal industries by the same mechanism, however they account only to less than 10% of TEQ and normally ca. 3% of TEQ (Weber et al. 2001). The total concentration of PCNs in waste incineration are in the same order of magnitude as PCDD/PCDFs with somewhat higher levels of PCNs in the gas phase (Takasuga et al. 2004) and similar levels in fly ash (Imagawa & Lee 2001). There are no official TEF factors for PCNs assigned by the WHO but only unofficial suggested TEFs from the research community (Falandysz et al. 2014).

Within the update of the South African NIP, the unintentional POPs inventory will be updated. In this frame also some assessment of unintentional PCNs can be made based on the emission factors of unintentional PCNs compiled in the Stockholm Convention PCN inventory guidance draft (UNEP 2019a).

7 Initial findings on potentially PCN and SCCP contaminated sites

7.1 Background

In accordance with the provisions of Article 6 (1) (e), Parties shall endeavour to develop appropriate strategies for identifying sites contaminated by chemicals listed in Annex A, B or C. POPs contaminated sites are generated along the life cycle of POPs – production, use in production, use of products and end of life treatment of POPs or POPs containing products. The PCN and SCCP guidance documents have listed potentially SCCP and PCN contaminated sites (Table 9, Table 10, UNEP 2019a,b,c).

Sites potentially contaminated with PCNs or SCCPs should be located in the country.

7.2 Potentially contaminated sites

7.2.1 Background

POPs are generating contaminated sites along the life cycle – production, use in production, use in products and end-of-life treatment including recycling (

, Table 10). This has been documented for PCBs (Weber et al 2018a). PCNs and SCCPs have similar physico-chemical properties. Therefore, they behave similarly as PCBs in respect to soil or sediment contamination.

7.2.2 Production sites of PCNs and SCCPs

Production sites of POPs are often contaminated with these POPs or unintentional POPs (Weber et al. 2008, 2018a,b). Therefore, (former) production sites of PCNs and SCCPs need to be assessed. SCCPs assessments on and around SCCP production sites have been conducted in China (Wang et al. 2018) and on sediments in Europe (ECB 2008; CEFAS 1999). For production sites of SCCPs and other CPs potentially containing SCCPs, the major assessments would include the production site, the related landfills, river sediments and soils in the surrounding. Also wildlife and the food chain in the area within a radius of about 10 km would be assessed for SCCP contamination and exposure risk (see

Table **9**).
The largest volume of POPs at former production sites are normally stored at landfills from the disposal of production waste (Götz et al. 2013; Weber et al. 2011; Vijgen et al. 2011). Sites where SCCPs and other CPs potentially containing SCCPs were/are produced can be contaminated with SCCPs (UNEP 2019b,c).
According to the Organochlorine industry in South Africa, SCCPs were not produced in South Africa. Currently it is not known to which extent the MCCPs produced in South Africa contain SCCPs and to which extent these were released from former production operation.

7.2.3 Use of PCNs and SCCPs in production

Sites where SCCPs or PCNs were used as additives in the production of related PVC products or rubber products can become contaminated or contaminate sediments if released into waterways. Companies which have produced articles or mixtures containing SCCPs or PCNs would be listed as potential PCN/SCCP contaminated sites requiring further assessment.

- PVC production site
- Sites where soft PVC products or other products containing SCCPs as additives were/are produced
- Sites where rubber production with PCN/CP additives were/are produced,
- Company sites where lubricants or metalworking fluids containing SCCPs were/are produced
- Sites where impregnated textiles, leather or paper were/are produced
- Sites where paints and coatings with PCN/CP additives were/are produced
- metal industries using or having used SCCPs, PCNs or PCBs as metal working fluids,

7.2.4 Sites where PCNs/SCCPs or PCN/SCCP containing products have been disposed

Landfills and dump sites containing products with PCN or SCCP additives or wastes from producers using or having used SCCPs or PCNs in production (e.g. landfills of rubber belt producers or producers of paints or PVC).

7.2.5 Sites where PCNs have been unintentionally produced and released

As shortly mentioned above, PCNs are unintentionally produced in thermal processes but also in some processes of chlorine in organochlorine industries (UNEP 2019a). Landfills where such waste is or has been disposed is contaminated with PCNs. Depending on the disposal approach also the surrounding of such landfills might be contaminated with PCNs.

Table 9. Potential SCCP-contaminated sites along the life cycle of SCCPs (UNEP 2019 b,c)

Life cycle stage	Activities	Locations (potential other POPs/PBTs)
SCCP production	Current and former production sites	Production site (other POPs produced at the site and UPOPs)
	Disposal of waste from SCCP production	Landfills related to waste from production (other POPs produced at the site; UPOPs)
	Former water discharge from production sites	River sediment and flood plains related to releases from production site (other POPs (formerly) produced at the site; UPOPs)
Sites where SCCP have been used in manufacturing of products and mixtures	Production sites of soft PVC	Site of production; Landfill site of related wastes; Impacted surface waters (sediment and flood plains) (PCBs)
	Production sites of rubber (using additives)	Site of production of rubber products; Landfill site of related wastes; Impacted surface waters (sediment and flood plains) (PCBs; PCNs)
	Production of paints and coatings	Sites of production (PCBs; PCNs, heavy metals)
	Production of impregnated textiles and leather	Textiles and leather production sites; Landfill site of related wastes; (PCBs; PCP; PFOS)
	Production of lubricants and metal working fluids (cutting oils, heat exchange oils; lubricants; solvents in chemical production)	Sites where SCCPs were used in lubricants and MWF productions Landfill site of related wastes; (PCBs; PCNs)
	Wood treatment (intumescent paint)	Wood treatment sites (PCP; PCNs, PCBs, endosulfan; HCH; DDT; mirex, chromium, arsenic)
Use of SCCPs	Use of SCCPs containing metal working fluids	Factories were metals are pressed, stamped, drilled, cut or otherwise treated where cutting oil was/is used (for factories operating before 1975 also PCNs or PCBs)
	Use of SCCPs containing lubricants	engines of automobiles, electric generators and wind power facilities, and for drilling in oil and gas exploration, petroleum refinery to produce diesel oil; food & beverage
	Application of SCCP containing paints for buildings, bridges, towers and other metal construction and waterproof paints and related removal	Sites where SCCP paints have been used and have been removed. Soil impacted from removal from buildings, bridges etc. (PCBs, PCNs, lead, cadmium)
	Ship painting and paint removal	Docks where ships were painted and repainted (PCBs; PCNs, DDT; Sn-organics, lead)
End-of-life treatment	Recycling and disposal of lubricants, MWFs and other SCCP liquids	Waste oil refineries; waste oil collection (PCBs)
	Recycling of (soft) PVC, certain rubber belts/products,	Recycling areas and landfills with disposed wastes
	Cable smouldering for copper and e-waste recycling (smelters; open burning)	Recycling areas and landfills with disposed wastes (UPOPs; PCDD/Fs, PCBs, PCNs)
	Scrapping/breaking of ships	Ship breaking/scrapping areas (PCBs; PCNs; DDT; Sn-organics)
	Open burning of SCCP impacted products	Related sites and sites were residues/ashes are disposed
	(Former) application of SCCP impacted sludge	Application/agricultural land

Table 10: Potential PCN-contaminated sites along the life cycle of PCNs (UNEP 2019a)

Life cycle stage; Sector	Activities	Locations (potential other POPs/PBTs)
PCN production	(Former) Production	Production site (other POPs produced at the site and UPOPs)
	Disposal of waste from PCNs production	Landfills related to waste from production (other POPs produced at the site and UPOPs)
	Former water discharge from production sites	River sediment and flood plains related to releases from production site (other POPs produced at the site)
Sites where PCNs have been used in production **(ca. 1930s to 1990s)**	Production of transformer and condenser	Site of production; Landfill site of related wastes; Impacted surface waters (sediment and flood plains) (PCBs)
	Production of chloroprene/Neoprene industry (formerly) using PCNs (used until early 2000)	Site of production; Landfill site of related wastes; Impacted surface waters (sediments and flood plains)
	Production of paints and coatings	Sites of production (PCBs; SCCP; heavy metals)
	Production of impregnated textiles and paper	Site of production; Landfill site of related wastes; (PCBs; PFOS; SCCP)
	Other uses of PCNs in production processes (cutting oils, heat exchange oils; lubricants; solvents in chemical production)	Sites where PCNs were used in these productions Landfill site of related wastes; (PCBs; SCCP)
	Wood treatment	Wood treatment sites (PCP; endosulfan; HCH; DDT; mirex)
Use of PCN-containing materials	Paints for buildings, bridges, towers and other metal construction and related removal	Sites where PCN paints have been used and have been removed. Soil impacted from buildings, bridges (PCBs, lead, Cd)
	Ship painting and paint removal	Docks where ships were painted and repainted (PCBs; DDT; Sn-organics)
	Use of PCNs in smoke grenades, fog ammunition and artillery and mortar projectiles.	Soil/environment at military sites where smoke grenades, inert artillery and mortar projectiles were used.
Unintentional PCNs (specific productions)	Chlorinated solvent production and related residues (“HCB waste” containing PCNs)	Disposal sites of residues from chlorinated solvent production and EDC production (HCB; HCBD; PCDD/F)
	(former) chloralkali production	Chloralkali sites and sites were residues where disposed (e.g. graphite electrode sludge) (PCDD/Fs)
End-of-life treatment	Electric Arc furnaces treating PCNs (and PCBs) painted scrap	Recycling areas and landfills with deposited wastes (PCBs)
	Ship scrapping/dismantling	Ship scrapping areas (PCBs; DDT; Sn-organics)
	Open burning or non-BAT incineration of PCNs-containing waste	Related sites and sites were residues/ashes are disposed
	Former application of PCN impacted sludge	Application/agricultural land

8 Gap analysis and need for monitoring and research for further inventory development

An important outcome of this initial assessment and inventory is a gap analysis and the need of future screening and monitoring of PCNs/PCBs and SCCPs in the country.

8.1 Information gaps on production of SCCPs and PCNs and suggested activity

Currently, no SCCP measurements are available for the MCCPs produced in South Africa. The only information is that the paraffin provider guarantee a short-chain (C10-C13) content of less than 1% which should remain the same for the chlorinated product then.
Analyses of different lots of MCCP for SCCPs and PCNs and other unintentional POPs should be conducted. Additionally the producer should be contacted to gather information on this topic.

8.2 Information gaps on import/export of SCCPs and PCNs and suggested activity

From the preliminary assessment more than 1000 tonnes of CPs are imported per year from India to South Africa and most likely more than this from China having the largest production capacity. Currently, there are no information on the share of SCCPs in these imported CPs. CPs produced in some Asian countries can contain a mix of CPs with various chain length partly including SCCPs (UNEP 2019 b,c). Therefore, imported CPs (also MCCPs and LCCPs) should be screened for SCCPs. Samples might be gathered at companies using CPs as additives in production (paints, sealants/adhesives, rubber, PVC, lubricants/metalworking fluids),

8.3 Information gaps on open application of SCCPs and PCNs and suggested activity

Open applications should be sampled and analysed. For optimizing sampling, the products (sealants, rubber, PVC, paint) can be screened with XRF to select only samples with a chlorine content of more than 1%.
For sampling, high risk groups should be given priority.

8.3.1 Conveyor and transmission belts (Rubber and other materials)

A large amount of rubber conveyor and transmission belts are imported to South Africa (Chapter 3.4.3). Also other conveyor and transmission belt materials can contain CPs as additives (UNEP 2019c,d). Due to the large amount and the high probability that rubber belts contain flame retardant additives, they are a priority product to be screened. The sampling should include different rubber materials and current used belts sample and belts at the end of life.
In addition to rubber belts from South Africa, also rubber belts from neighbouring countries could be screened for SCCPs.

8.3.2 Other rubber products

Also other rubber products in particular flame retarded products or rubber containing plasticiser might contain SCCPs. Chloroprene rubber produced before 2000 might contain PCNs as additives. XRF can be used for sample pre-screening of rubber products.

8.3.3 PVC products

A wide range of PVC products have been found contaminated with SCCPs (see Annex 1).

- Cables (in current use and in construction)
- Toys
- Sporting equipment
- Building equipment (flooring, foils)

For PVC the pre-selection due to chlorine content is difficult since PVC contains about 50% chlorine. Soft PVC with 50% additive contains approx. 25% chlorine. It could be assessed if soft PVC containing CPs can be detected due to their higher share of chlorine.

8.3.4 Specific consumer product categories found contaminated in other studies

Consumer products that have been found contaminated with SCCPs include the following:

- Kitchen blenders (Yang et al. 2016)
- Baking oven (Gallistl et al. 2018)
- Consumer products on the European market (Annex 1).

Selected products can also be screened in South Africa.

8.3.5 Sealants and adhesives

Sealants/adhesives from buildings older than 1980s can contain PCBs/PCNs and should be one important sample category for the study since it is a major open application of PCBs in industrial countries.
Sealants used after 1980s might contain SCCPs and should also be screened for chlorine and samples should be analysed.
Prof. Okonkwo's group have already started with XRF screening (Annex 4; Nevondo et al. 2019;).
Also sealants/adhesives on the current marked might contain chlorinated paraffins and can be assessed.

8.3.6 Water proof and fire retardant paints,

Water proof and fire retardant paints should be sampled on the current market.
Also paints in specific uses (swimming pools, dams, metal constructions) should be sampled and analysed. For this application, a differentiation of older objects (built before 1980s) which could contain PCNs and PCBs should be made and analysed accordingly.
For the inventory, the former use of PCNs, PCBs and SCCPs in paints for corrosion protection of metal constructions and for paints used in swimming pools and other underwater paints and lacquers uses should be assessed.
As a first step the producers, users/industries and importers of paints (including chlorinated rubber paints and lacquers and PVC copolymer paints and thinners) should be interviewed to obtain information on the former use of paints containing PCNs, PCBs and SCCP in the country (see the questionnaire in PCN and SCCP inventory guidance documents). This would include:

- The time when PCNs, PCBs and SCCP have been used in paints;
- Type of paints in which PCNs, PCBs and SCCPs have been used;
- Application areas of paints containing PCNs, PCBs and SCCPs in the country;
- Known individual constructions in which paints containing PCNs, PCBs and SCCPs (might) have been used.

An inventory of major metal/steel constructions (steel bridges, steel towers, pressure pipes, pipelines, water sluices, electricity poles etc.) which have been built before 1980s should be compiled. Information on which anti-corrosion paints/lacquers have been used should be included. The inventory should also assess the former use of paints containing PCNs and PCBs in ships including military ships. Within this assessment, information on the areas where those ships have been painted and repainted should be collected. Such areas may be contaminated with PCNs and PCBs and possibly also with other chemicals such as DDT, tributyltin and heavy metals (Eklund & Eklund 2014; ELSA 2016; Johnsen & Engoy 1999).

In a Tier III assessment (selected) metal constructions should be monitored for the presence of PCNs, PCBs and SCCPs. The assessment could also assess contamination in the surrounding in particular if paints have been removed by abrasive blasting (e.g. sand/air-blasting).
For the inventory the estimated total amount of the remaining PCN and PCB paints and painted objects should be noted in the inventory report and the NIP. This should also include major contaminated objects like bridges, towers, ships, silos or other objects.
Assessment in South Africa where the team has relatively easy access:

- Locations of removal of paints from ships
- Swimming pools (public and private)
- Metal constructions

8.3.7 Lubricants and metal working fluids,

Lubricants and metal working fluids currently on the market and in use can be pre-screened with XRF to select chlorine positive samples for further SCCP analysis.

8.3.8 Waste oils and recycling of waste oils.

Waste oils gathered in South Africa can be screened for PCNs, PCBs and SCCPs. This can give an indication if the oils gathered (e.g. car oils from garage or lubricants from metal processing companies) have high or low use of POPs in oils in use.
Such screening can also be made at power companies maintenance shops where transformers are repaired.

8.4 Information gaps on PCNs in closed application and suggested action

There are no studies or information on technical PCNs in closed applications such as capacitors or transformers. Currently, oils of transformer and possibly other equipment and related waste oils are assessed for PCBs in the SADC region with the involvement of the African Centre.

8.4.1 Assessment of transformers and transformer oils

Assessment of waste oils can be conducted within the SADC PCB management project. Samples from transformer oils and wastes from transformer oil maintenance are currently analysed for PCBs and could be screened for PCNs. In particular, false positive samples should be analysed for PCNs and other contaminants used polychlorinated terphenyls (PCTs) or Ugilec[11].
The option to develop a GC/MS method that covers PCBs and PCNs (and possibly SCCPs) should be assessed.

[11] The PCB substitute Ugilec is a mixture of tetrachlorobenzyltoluenes (TCBTs)

8.4.2 Assessment of capacitors

The Basel guidance claims that PCNs can be screened by nametag like PCBs (UNEP 2017c). This is most likely not true since at the time of PCN use they were not specifically regulated like the PCBs and most likely not labelled. Only older capacitors produced before 1980s might be impacted. In the inventory of PCBs in capacitors, samples with false positive results from chlorine screening would have the highest priority.

8.5 Information gaps on unintentional produced PCNs and suggested action

In thermal processes like incineration, PCNs are formed together with PCDD/PCDFs, PCBs and chlorobenzenes, such as HCB and PeCB. The UNEP toolkit recommends that for these processes PCDD/PCDF are used for inventory purposes.

For specific industrial processes of the chlorine and organochlorine industry PCNs are formed as a major unintentional POP. This includes production of chlorinated paraffins, chlorine production and VCM/EDC production (see Chapter 6).

8.6 Information gaps on sites contaminated with SCCPs and PCNs and suggested activities

There are a range of potential contaminated sites polluted with SCCPs or PCNs (see Chapter 7 and

, Table 10). Soils, sediments or biota including e.g. eggs could be screened for these POPs and possibly other pollutants.

8.7 Monitoring of selected biota samples for environmental pollution status and background concentration of PCNs, SCCPs and PCBs

It was decided by the environmental ministry to also assess environmental samples on PCN, SCCP and PCB contamination level.

Professor Henk Bouwman (North-West University; Bird biology and Ecology Research Group and Persistent Organic Pollutant and Toxicant Research Group) was involved and selected for this task. He is one of the most experienced environmental researchers on POPs in the Africa and the Southern Hemisphere.

Samples were selected which includes eggs and biota.

Since Prof. Bouwman does not operate an own laboratory, a collaboration partner with strong expertise in analysis of PCNs and SCCPs in biota was sought. Dr. Weber contacted selected research groups and got an agreement from Dr. Natsuko Kajiwara from the National Institute of Environmental Science (NIES) of Japan (Tsukuba/Japan). The institute operates the laboratory which is responsible for setting up the standard analysis of SCCPs and PCNs in Japan including products, recycling and waste.

NIES agreed to analyse a set of eggs and other selected biota from the environment. Samples are already taken and Prof. Bouwman will send the samples later this year to Japan after possibly some additional samples are taken.

9 Establishment of PCN and SCCP analysis in South Africa and cooperation

Before this project no PCN and SCCP analysis or plan for analysis existed. However, the group of Prof. Okonkwo already had an XRF equipment for screening and GC/MS equipment suitable for PCN and SCCP analysis.

Within the project PCN analysis was established on GC/LRMS. For this a suitable standard solution was purchased and standard analysis was selected. PCN standard analysis is described in the Stockholm Convention Draft Guidance on Sampling, Screening and Analysis of Persistent Organic Pollutants in Products and Articles (UNEP 2017d); see Annex 2.

For the establishing of SCCP/CP analysis a Standard Operation Procedure has been developed by the group of Rio De Janeiro University, Brazil in cooperation with Hohenheim University, Germany (Annex 3).

Also contact has been established between these institutes and Professor Okonkwo's group. Furthermore, contacts were established between the group of Prof. Henk Bouwman and the POPs group in the National Institute of Environmental Studies in Tsukuba, Japan (Dr. Natsuko Kajiwara) for the analysis of biota samples such as eggs. Here the approach is that selected samples from Prof. Bouwman are sent to Japan for analysis.

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Annexes

Annex 1: Consumer products containing SCCPs on the EU market

Consumer products assessed in European Union members states and Norway between 2013 and 2017 and found to contain SCCPs levels above regulatory limits (1500 mg/kg).

Table A1. Consumer products containing SCCPs on the EU market 2013-2017 (UNEP 2018)[12]

2017	Sports equipment: Boxing gloves	4400
	Sports equipment: Gym ball	8500
	Toy pistol (plastic cord)	7000
	Bathtub pillow	17 000
	Electric shaver (cable)	9800
	Hobby/sports equipment: Hot pack	4000
	Hobby/sports equipment: Exercise tube	90 000 (handles)
	Speaker (cord)	10 000
	Radio controlled car (tyres)	17 000
	Claw hammer (Handle)	7000
	In-ear headphones (USB cord)	3000
	LED candle (cord)	13 000
	Power cord	26 000
	Table cloth	6 000
	Selfie stick (cord)	45 700
	USB cable	16 000
	Bath toy	13 400
	Game controller	43 000
	Plastic doll	8 600
	Babies' sleeping bag/footmuff (packaging)	40 000
	Babies' sleeping bag (anti-slip knobs)	18 000
	Handle (cycle parts)	3 500
	Breastfeeding pillow (packaging)	60 000
	Hammer (handle)	2 800
	Sports equipment: Yoga mat	8 000
	Erotic article	4 400
2016	Lighting chain (cord)	7 000
	Sports equipment: Yoga mat	2 300
	Sports equipment: Abs trainer	4000
	Steering wheel cover	4 600
	Long sleeved sweater (print)	2 300
	Steering wheel cover	3 000
	Motor vehicle sidelight (cable)	2 600
	USB-cord	2 570
	Selfie Stick	1 600
	Digital thermometer (cable)	1 100

[12] UNEP 2018. Draft technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with short-chain chlorinated paraffins. UNEP/CHW/COP.14/7/Add.2

	Stickers (toys)	9 000
	Stickers (toys)	14 000
	Mobile phone case	4 400
	Sports equipment: Baseball glove	13 600
	All-purpose mat	3 600
	Sports equipment: Yoga mat	6 400
	Sports equipment: Yoga mat	5 400
	Sports equipment: Yoga mat	32 000
	Sports equipment: Yoga mat	69 000
	Sports equipment: Yoga mat	3 500
	Sports equipment: Fitness gloves	1 800
	Rain cover for pushchair	7 300
	Extension lead	47 000
	Extension lead	17 000
2015	Kettle (cable)	36 400
	Game Controller (cable)	19 000
	Rubber knife	2 600
	Mobile phone cover	2 600
	Cloche cover (garden equipment)	4 000
	Toilet seat for children	710
	Plastic doll	3 170
	Toy doctor set (stethoscope)	49 100
	Electric kettle (cord)	5 000
	Beach ball	3 100
	Bouncy toy	5 000
	Bathmat	5 200
	Shower curtain	4 900
	Stickers (toys)	15 000
	Stickers (toys)	2 000
	Bathmat	5 300
	Shower hose	47 000
	Earphones	2 800
2014	Wallet (artificial leather)	1 300
	Handbag (artificial leather)	14 000
	Mobile phone bag (artificial leather)	1 100
	Brush case black (artificial leather)	3 500
	Toiletry bag	11 700
	Handbag (artificial leather)	3 800
	Handbag (artificial leather)	3 200
	Bag (artificial leather)	2 700
	Small bag / purse (artificial leather)	1 700
	Wallet case for smartphones (artificial leather)	1 800
	Purse (artificial leather)	2 000
	Pencil case (artificial leather)	5 000
	Handbag (artificial leather)	10 000
	Toiletry bag (artificial leather)	1 300
	Toy car (tyres)	8 300

	Sports equipment: Exercise mat	16 000
	Sports equipment: Exercise mat	49 000
	Sports equipment: Jump rope	22 000
	Plastic cooking set (plastic bag)	8 800
2013	Beauty case	12 000
	Squeeze toy (chicken)	100 000
	Plastic bath toy	71 000
	Pirate slap-on bracelet	31 000
	Doll with accessories	15 000
	Police costume (transparent plastic pocket)	57 000
	Replaceable wall decorative stickers	18 000
	Pirate costume for children	2 800 (belt) and 1900 (vest)
	Plastic toy figures	83 000

Annex 2: GC/MS analysis of PCNs (instrumental setting; chromatogram)

GC/MS conditions for PCNs (example) (UNEP 2017d)[13]

An example of instrumental setting for the GC/MS analysis of PCNs is given in Table A2 and the exact masses of native and ^{13}C-labled PCNs in Table A3.

A chromatogram of PCN homologues from GC/MS analysis is shown in Figure A1.

Table A2: PCP GC/MS conditions (example)

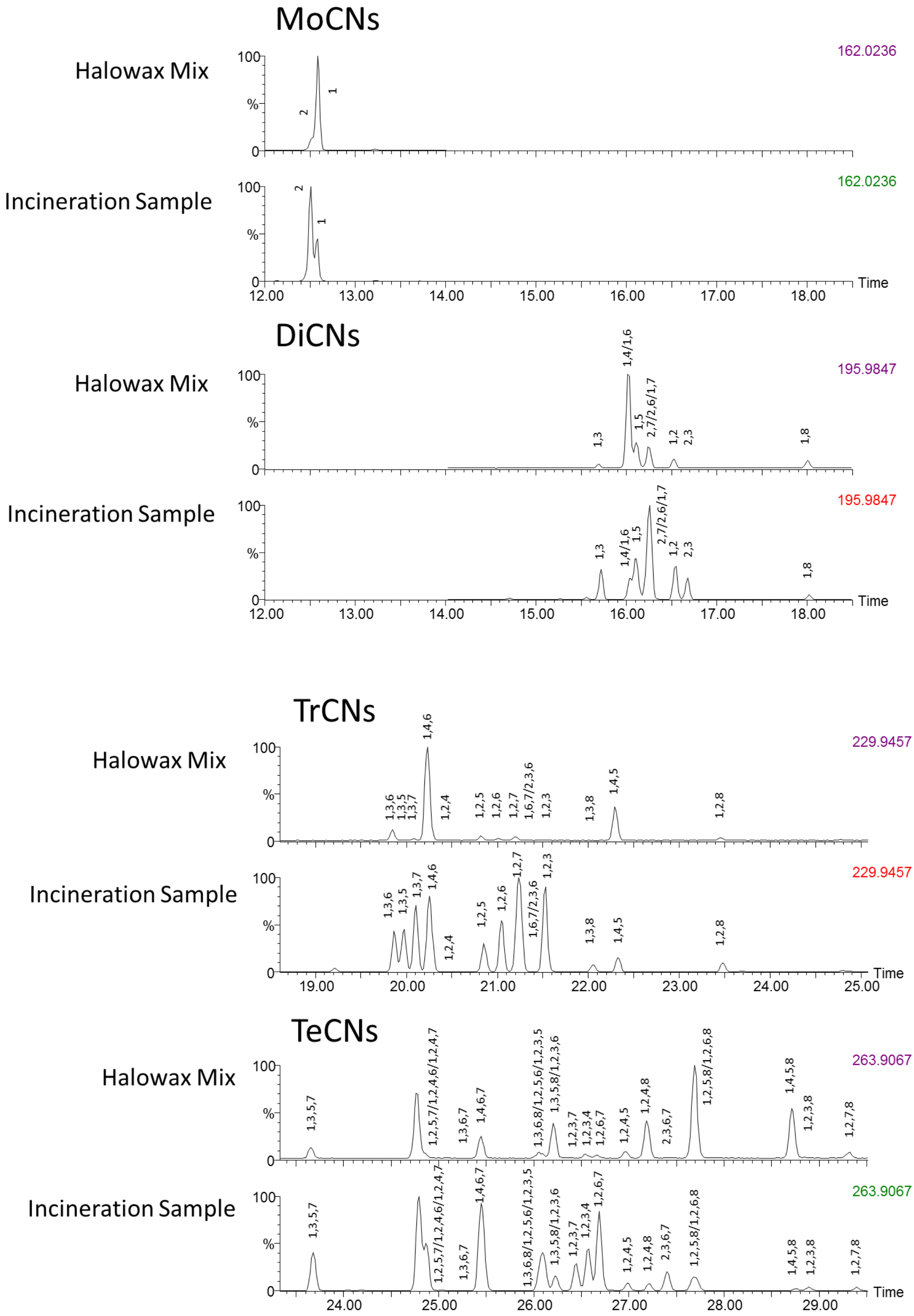
GC column	DB-5MS（Agilent Technologies/J&W） fused silica capillary column ID 0.32 mm, length 60 m, thickness 0.25 μm
Oven Temp.	90°C (2 min hold) - (20°C/min)→160°C - (3°C /min) → 245° C -(5 C/min) →310° C（2 min hold）
Injection	On-column or Split less
Injector Temp. (On-column)	90 C(1 min hold)－（100 C/min）→300 C
Injection volume	1～2 μL
HRMS condition	Autospec Ultima （Waters/Micromass）
Ionization	EI
Ionization voltage	35 V(35～70 V)
Ionization current	500 μA
Accelerating voltage	8 kV
Ion source Temp.	290～300 °C
Interface Temp.	290～300 °C
MS resolution	10 000

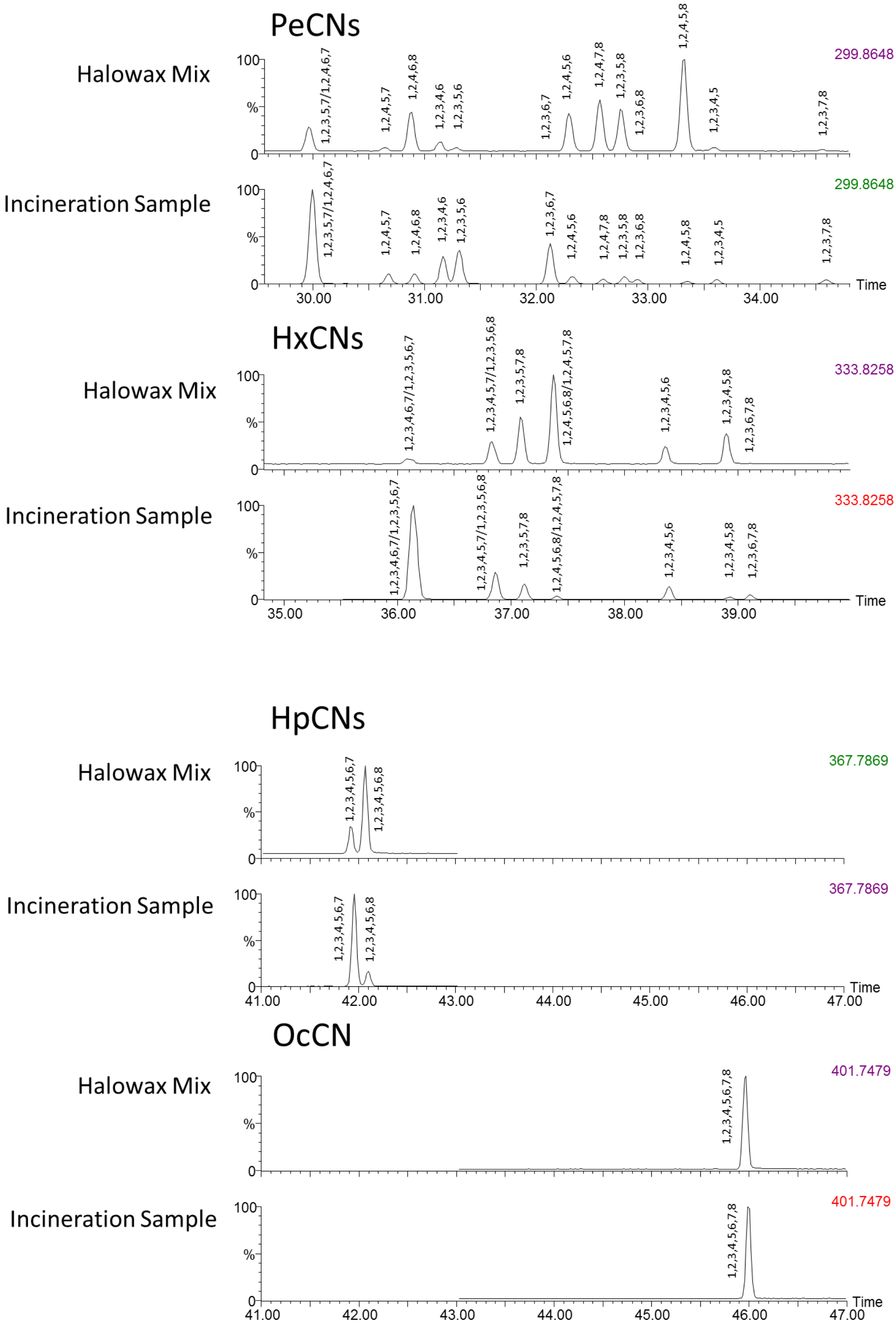
Table A3: Masses of detected ions (*m/z*'s) and isotope ratio for PCNs

	CL degree	M^+	$(M+2)^+$	$(M+4)^+$
Native PCN	*MoCNs (not listed)*	*162.0237(100)*	*164.0208(32.6)*	
	DiCNs	195.9847(100)	197.9818(64.5)	
	TrCNs	229.9457(100)	231.9428(96.5)	
	TeCNs	263.9067(77.8)	265.9038(100)	
	PeCNs		299.8648(100)	301.8619(64.3)
	HxCNs		333.8258(100)	335.8229(80.3)
	HpCNs		367.7869(100)	369.7839(96.3)
	OcCN		401.7479(89.1)	403.7450(100)
Internal Standard for PCN[14]	$^{13}C_{10}$-DiCN	206.0183(100)	208.0152(64.0)	
	$^{13}C_{10}$-TeCNs	273.9402(78.2)	275.9373(100)	
	$^{13}C_{10}$-PeCNs		309.8983(100)	311.8954(64.0)
	$^{13}C_{10}$-HxCNs		343.8593(100)	345.8564(80.0)
	$^{13}C_{10}$-HpCN		377.8204(100)	379.8174(95.9)
	$^{13}C_{10}$-OcCN		411.7814(89.4)	413.7785(100)
	$^{13}C_{12}$-DiCB*,**	234.0406(100)	236.0376(65.6)	
	$^{13}C_{12}$-TrCB*	268.0016(100)	269.9986(98.0)	
	$^{13}C_{12}$-TeCB**	301.9626(78.2)	303.9597(100)	
	$^{13}C_{12}$-PeCB*		337.9207(100)	339.9177(65.3)
	$^{13}C_{12}$-HxCB*		371.8817(100)	373.8788(81.5)
	$^{13}C_{12}$-OcCB*		439.8038(87.8)	441.8008(100)

13 UNEP (2017d) Draft Guidance on Sampling, Screening and Analysis of Persistent Organic Pollutants in Products and Articles. Relevant to the substances listed in Annexes A, B and C to the Stockholm Convention on Persistent Organic Pollutants in 2009, 2011, 2013 and 2015.

14 Up to now, not sufficient 13C10-PCN standards for internal standardization, so alternatively 13C12- PCB are used.


MoCNs
Halowax Mix
162.0236
Incineration Sample
162.0236
DiCNs
Halowax Mix
195.9847
Incineration Sample
195.9847
TrCNs
Halowax Mix
229.9457
Incineration Sample
229.9457
TeCNs
Halowax Mix
263.9067
Incineration Sample
263.9067
Time
%



※Halowax Mix： Halowax 1000,1001,1013,1014,1031,1051,1099 mixture

Incineration sample：flue gas sample

Figure A1: Chromatogram of PCN congeners from technical mixtures and waste incineration[15]

[15]Noma Y, Yamamoto T, Sakai S (2004) Congener-specific composition of polychlorinated naphthalenes, coplanar PCBs, dibenzo-p-dioxins, and dibenzofurans in the Halowax series. Environ Sci Technol. 38, 1675-80.
Takasuga T, Inoue T, Ohi E, Senthil Kumar K (2004) Formation of Polychlorinated Naphthalenes, Dibenzo-p-Dioxins, Dibenzofurans, Biphenyls, and Organochlorine Pesticides in Thermal Processes and Their Occurrence in Ambient Air. Arch. Environ. Contam. Toxicol. 46, 419-431.

Annex 3: Standard Operation Protocol for SCCP/CP analysis by GC/ECNI-MS

Operating Protocol for Chlorinated Paraffins Determination by GC/ECNI-MS-SIM

Yago Guida; Instituto de Biofísica Carlos Chagas Filho; Universidade Federal do Rio de Janeiro, Brazil
Jannik Sprengel, University Hohenheim, Germany

This protocol is mainly based on the following literature:
Reth M, Zencak Z, Oehme M. **New quantification procedure for the analysis of chlorinated paraffins using electron capture negative ionization mass spectrometry**. *J. Chromatogr. A* 2005; 1081 (2): 225–231. doi: 10.1016/j.chroma.2005.05.061;
Reth M & Oehme M. **Limitations of low-resolution mass spectrometry in the electron capture negative ionization mode for the analysis of short- and medium-chain chlorinated paraffins**. *Anal. Bioanal. Chem.* 2004; 378 (7): 1741–1747. doi: 10.1007/s00216-004-2546-9;
Sprengel J & Vetter W. **Synthesis and characterization of eight single chain length chlorinated paraffin standards and their use for quantification**. *Rapid Commun Mass Spectrom*. 2019; 33: 49-56. doi: 10.1002/rcm.8310.
Sprengel J, Wieselmann S, Kröpfl A, Vetter W. **High amounts of chlorinated paraffins in oil-based vitamin E dietary supplements on the German market**. *Env. Int*. 2019; 128: 438-445. doi: 10.1016/j.envint.2019.04.065.

Rio de Janeiro, June 2019.

This protocol was created to help to implement analysis of short- and medium-chain chlorinated paraffins (CPs) by gas chromatography coupled with electron capture negative ion mass spectrometry operated in selected ion monitoring mode (GC/ECNI-MS-SIM) and it is divided in three steps. However, you must read the references above to fully understand the method (preferentially in the order they were presented).

Step 1: Standard preparation

CP homologs with different chlorine contents are needed (**at least five different Cl% should be used**). Thus, starting with 3 CP homologs with different chlorine content (**SCCP 51.1% Cl; SCCP 55.5% Cl and SCCP 63% Cl**), you just need to make a 1 + 1 mixture of them and you will have two additional chlorine contents, which is enough to make a linear regression (SCCP 51.1% Cl + SCCP 55.5% Cl = **SCCP 53.3% Cl** and SCCP 55.5% Cl + SCCP 63% Cl = **59.25% Cl**). The same should be made with MCCP standards. **MCCP 42% Cl; MCCP 52% Cl and MCCP 57% Cl** can originate **MCCP 47% Cl (42% + 52%) and MCCP 54.5% Cl (52% + 57%).**

Once all CP homologs with different chlorine content are prepared, you can make a work dilution according to the concentrations you expect to measure in the analysed samples, adding the injection/internal standard (ISTD)*, which must match the same concentrations in the standards and in the sample extracts you aim to analyse. CP homologs concentrations do not need to vary. The linear regression shall be made with the chlorine content variation of the homologs.

** In this case 6'-MeOH-BDE 66 (BCIS), synthesized by Prof. Vetter's work group, is used as ISTD.*

Step 2: Instrument setup

CPs can be quantified by monitoring the two most abundant isotopes of the [M-Cl] ¯ ions of CPs in the SIM mode. All m/z values used for CP-analysis are listed in Table A4. It is necessary to make a SIM run for each CP chain-length. Thus, a total of 8 SIM runs will be necessary to quantify SCCPs and MCCPs by GC/ECNI-MS-SIM*. The analysis should be carried out using the following setup:

- 30 m column with **DB-5** phase (or equivalent)
- Temperature program: 50°C (1 min) – 10 °C/min - 300 °C (14 min)
- Ion source: 150 °C; Quad: 150 °C; transfer line: 300 °C
- PTV or split/splitless injector

Table A4: *m/z* values monitored in GC/ECNI-SIM runs.

	Used for	measured ions (*m/z*)	Dwell time [ms]
SIM 01	C_{10}-CP quantification	243; 245; 279; 277; 313; 315; 347; 349; 381; 383; 417; 415; 451; 449 ***+ ISTD ions****	28
SIM 02	C_{11}-CPs quantification	257; 259; 293; 291; 327; 329; 361; 363; 395; 397; 431; 429; 465; 463 ***+ ISTD ions****	28
SIM 03	C_{12}-CPs quantification	271; 273; 307; 305; 341; 343; 375; 377; 409; 411; 445; 443; 479; 477 ***+ ISTD ions****	28
SIM 04	C_{13}-CPs quantification	285; 287; 321; 319; 355; 357; 389; 391; 423; 425; 459; 457; 493; 491 ***+ ISTD ions****	28
SIM 05	C_{14}-CPs quantification	299;301; 335; 333; 369; 371; 403; 405; 437; 439; 473; 471; 507; 505 ***+ ISTD ions****	28
SIM 06	C_{15}-CPs quantification	313; 315; 349; 347; 383; 385; 417; 419; 451; 453; 487; 485; 521; 519 ***+ ISTD ions****	28
SIM 07	C_{16}-CPs quantification	327; 329; 363; 361; 397; 399; 431; 433; 465; 467; 501; 499; 535; 533 ***+ ISTD ions****	28
SIM 08	C_{17}-CPs quantification	341; 343; 377; 375; 411; 413; 445; 447; 479; 481; 515; 513; 549; 547 ***+ ISTD ions****	28

**Whether using BCIS as ISTD, add ions 79; 81; 261; 259 in each SIM run.* Dwell time can be changed to optimize the resolution of the chromatogram according to your needs.

Exemplary GC/ECNI-MS-SIM setup

Sample Inlet: GC
Injection Source: GC ALS
Mass Spectrometer: Enabled

Oven
Equilibration Time 0,5 min
Oven Program On
50 °C for 1 min
then 10 °C/min to 300 °C for 14 min
Run Time 40 min

Front Injector
Syringe Size 10 µL
Injection Volume 1 µL
Solvent A Washes (PreInj) 5
Solvent A Washes (PostInj) 5
Solvent A Volume 8 µL
Solvent B Washes (PreInj) 5
Solvent B Washes (PostInj) 5
Solvent B Volume 8 µL
Sample Washes 0
Sample Wash Volume 8 µL
Sample Pumps 6
Dwell Time (PreInj) 0 min
Dwell Time (PostInj) 0 min
Solvent Wash Draw Speed 300 µL/min
Solvent Wash Dispense Speed 6000 µL/min
Sample Wash Draw Speed 300 µL/min
Sample Wash Dispense Speed 6000 µL/min
Injection Dispense Speed 6000 µL/min
Viscosity Delay 0 sec
Sample Depth Disabled
Injection Type Standard
L1 Airgap 0,2 µL

Sample Overlap
Sample overlap is not enabled

Front PTV Inlet He*
Mode Pulsed Splitless
Heater On 80 °C
Pressure On 9,7853 psi

Total Flow On 104,2 mL/min
Septum Purge Flow On 3 mL/min
Temperature Program On
80 °C for 0,01 min
then 500 °C/min to 300 °C for 2 min
then 10 °C/min to 260 °C for 0 min
Run Time 40 min
** If you don't have a Front PTV inlet injector, you won't be able to setup the temperature program. In this case, setup the temperature as 280 °C.*

Gas Saver On 20 mL/min After 2 min
Injection Pulse Pressure 25 psi Until 1 min
Purge Flow to Split Vent 100 mL/min at 2 min
Cryo Off

Thermal Aux 2 {MSD Transfer Line}
Heater On
Temperature Program On
300 °C for 0 min
Run Time 40 min

Column #1
HP-5MS 5% Phenyl Methyl Siloxane: 1077.58889
HP-5MS 5% Phenyl Methyl Siloxane
325 °C: 30 m x 250 µm x 0,25 µm
In: Front PTV Inlet He
Out: Vacuum

(Initial) 50 °C
Pressure 9,7853 psi
Flow 1,2 mL/min
Average Velocity 39,923 cm/sec
Holdup Time 1,2524 min
Flow Program On
1,2 mL/min for 0 min
Run Time 40 min

Signals
Test Plot Save Off
50 Hz
Test Plot Save Off
50 Hz
Test Plot Save Off
50 Hz
Test Plot Save Off
50 Hz

MS ACQUISITION PARAMETERS

General Information

Tune File : ncich4.u
Acquistion Mode : SIM

MS Information

Solvent Delay : 8.00 min

EMV Mode : Gain Factor
Gain Factor : 14.00
Resulting EM Voltage : 1541

[Sim Parameters]

GROUP 1
Group ID : 1
Resolution : Low
Plot 1 Ion : 261.00
Ions/Dwell In Group (Mass, Dwell) (Mass, Dwell) (Mass, Dwell) (Mass, Dwell)
Example: BCIS ions (79.00, 28) (81.00, 28) (259.00, 28) (261.00, 28)
This step will change for each SIM run. You must select the ions according to the CP chain-length as shown in Table A4. In the end you will have 8 different injection methods, in which you will run each sample. Do not forget to save all SIM runs as different methods.

[MSZones]

MS Source : 150 C maximum 300 C
MS Quad : 150 C maximum 200 C

TUNE PARAMETERS for SN: US94343906

Trace Ion Detection is OFF.

EMISSION : 49.443
ENERGY : 119.076
REPELLER : 3.988
IONFOCUS : 96.800
ENTRANCE_LE : 15.500

EMVOLTS : 1294.118
Actual EMV : 1541.18
GAIN FACTOR : 13.50
AMUGAIN : 1742.000
AMUOFFSET : 128.625
FILAMENT : 1.000
DCPOLARITY : 0.000
ENTLENSOFFS : 21.082
MASSGAIN : -782.000
MASSOFFSET : -32.000
CI Flow Rate: 40
CI A/B Gas : 1

Step 3: Quantification

After the setup of the instrument and method development you will be ready to inject your standards and sample extracts in each SIM run. Starting with the standards, every different Cl content (SCCPs 51.5%, 53.3%, 55.5%, 59.25%, 63% and MCCPs 42%, 47%, 52%, 54.5% 57%) have to be inject in the different SIM runs. Therefore, the 5 SCCPs with different Cl% have to be inject four times each, being one in each method (SIM runs 01, 02, 03 and 04; according to Table A4) and the 5 MCCPs with different Cl% have to be inject four times each, being one in each method (SIM runs 05, 06, 07 and 08; according to Table A4). After a total of 40 runs, 20 runs for SCCPs and 20 runs for MCCPs, you are ready to start sample injections. The samples will be injected 4 times for SCCPs and 4 times for MCCPs, just like the standards. Once you have the chromatograms, you will open one by one and extract the selected ions (you might have to do it more then once for each CP chain-length, cause generally you can only extract 6 ions per time).

Beginning with the standards, each ion of the ISTD and CP with different Cl% have to be integrated and their area computed for the next step in an Excel file. The computed area of each ion will be typed in the Excel file "CP_quantification", which is ready to use. The "Sample" sheet in the file can be duplicated for every sample you need to quantify. CP concentrations in ng μL^{-1} and chlorine content (Cl%) will be given. Then, CP concentrations can further be corrected according to the sample mass/volume analysed.

It is extremely important, especially for setups using LRMS, to ensure a precise ingtegration of the correct CP humps. Therefore, it is elementary that you get to known the typical hump shapes of CPs, especially as they appear on your system. Be careful if you have any peak which do not match the standard chromatogram. If there is any clearly discernible peak on top of the CP hump, the interference must be integrated separately afterwards and its area have to be deducted from the integration of the total area (CP + interference). Starting with the standards will make you familiar with its chromatogram, which is necessary to recognize any interference afterwards. For some examples of CP shapes, please check the chromatograms in Figure A2.

Additionally, you have to consider the interferences between the CPs themselves. On LRMS systems, especially CPs which are 2 and 5 carbon atoms apart can lead to big interferences. On a 30 m column, CPs which are 5 C apart can be separated via retention time. By comparing the retention times of the samples with the respective standards, the overlapping hump peak in the sample can generally be sharply separated between the two CP species. However, overlaps between CPs that are 2 C apart cannot be separated via retention time. Here, it is important to know which CP chain length (+2 or -2) is causing the interference. In tbis case, the peak area contribution of the desired chain length can be calculated from the measured isotope ratio, and the theoretical isotope ratios of the desired CPs and the interference. Generally, one can say:

- If **$C_{(x+2)}$-CPs are much more abundant**, than the **Cl_{8-10} homologs** of C_X-CP are affected and need correction
- If **$C_{(x-2)}$-CPs are much more abundant**, the **Cl_{5-7} homologs** of C_X-CPs are affected and need correction

Be careful, as sometimes additional interferences of another origin can occur in your sample that also need arithmetic correction.

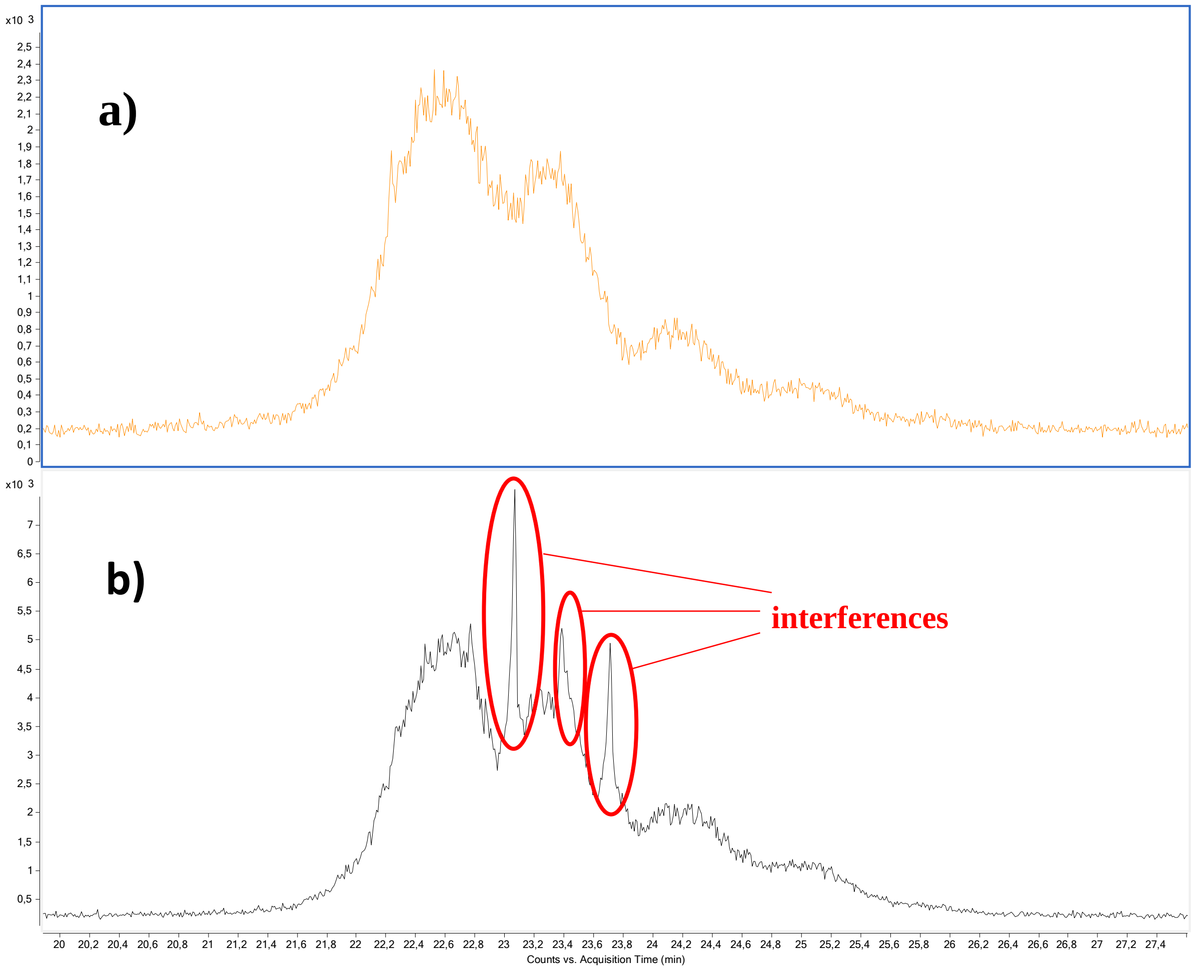


Figure A2: examples of **a)** CP-only hump and **b)** CP hump with interference peaks.

This document must come with the Excel file "CP_quantification" and the four references in which it is based.
Don't hesitate to contact me if you have any question.

Emails: yagoguidarj@gmail.com; guidays@biof.ufrj.br
Skype: yagoguidarj

Annex 4: Short Paper for global POPs Conference 39th International Symposium on Halogenated Persistent Organic Pollutants (Dioxin2019)

X-RAY FLUORESCENCESCREENING OF OPEN POLYCHLORINATED NAPHTHALENES (PCNs) AND SHORT CHAIN CHLORINATED PARAFFINS (SCCPs) CONTAING CONSUMER PRODUCTS IN SOUTH AFRICA.

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Introduction

Polychlorinated naphthalenes (PCNs) were listed as POPs in the Stockholm Convention on Persistent Organic Pollutants (POPs) in 2015. More recent in 2017 short-chain chlorinated paraffins (SCCPs; C10 to C13 and a content of chlorine greater than 48% by weight.) were listed as POPs in the Stockholm Convention. Additionally, a limit for the presence of SCCPs in other chlorinated paraffin mixtures was set at 1% by weight. SCCPs are listed with a wide range of specific exemptions for production and use. South Africa as a Party of the Stockholm Convention need to assess the presence, use and lifecycle of SCCP and PCNs in the country.

PCNs are a group of 75 congeners, a family of two-ringed aromatic compounds containing from one to eight chlorine atoms per naphthalene molecule[3-4] (Figure 1) while only DiCNs to OctaCNs are listed in the Convention. PCNs were mainly produced commercially from 1930th to 1970th and for some uses until 2000. and were complex mixtures of PCNs which range from liquids to waxes with high melting points.

Short chain chlorinated paraffins (SCCPs) listed as POPs are n-paraffins that have a carbon chain length of between 10 and 13 carbon atoms and a degree of chlorination of more than 48% by weight.

These synthetic compounds are mainly used in metal working fluids, sealants, as flame retardants in rubbers and textiles, in leather processing and in paints and coatings[1,2,6]. Due to the risks caused by the substance to the health and environment the marketing and use of these substances has been restricted in the European Union[6]. There is a weight of evidence that SCCPs are persistent, bioaccumulating and toxic and have potential for long-range environmental transport. The structure of two examples of SCCP compounds ($C_{10}H_{17}C_{l5}$ and $C_{13}H_{22}C_{l6}$) are shown in Fig 2.

Due to their high chemical and thermal stability, inertness, water repellent, flame retardant, and fungus-resistance PCNs and SCCPs have been commercially produced and used as additives in different consumer products. While the use of PCNs have stopped around 2000, the use of SCCP continues with a range of exemptions in the Stockholm Convention listing [1,2,7,8]. Both have been used in the in cables in electrical industry, in.in textiles, plastic and rubber additives, sealants, oil additives such as hydraulic fluids, lubricants [1,2,9-11]. PCBs were also used in these open applications until 1970s PCNs also occur as trace contaminants in commercial polychlorinated biphenyl (PCBs) mixtures[11]. According to Hogarh PCNs as well as SCCPs remain one of the least researched organohalogens in the continent of Africa[12]. POPs containing products like electronic gadgets and industrial wastes are frequently shipped from developed countries to developing countries which might be a source of shifting of POPs pollution burden from the industrialised nations to developing ones[13].

To date, there is no report on the concentration of PCNs and SCCPs on consumer products in South Africa. The main objective of this study was to develop the PCN and SCCP analysis in South Africa and screen and measure consumer products such as sealants, old paint coatings, PVC products, cable insulation and rubber materials. The presence of chlorine in consumer products may suggest the occurrence of PCNs, SCCPs, PCNs or other chlorinated additives in consumer products.

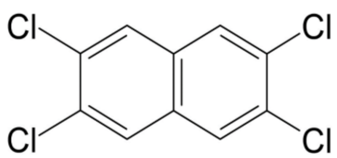

Figure 1. Structure of a polychlorinated naphthalene (PCN)

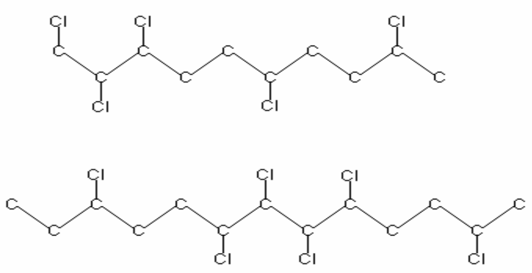

Figure 2. Structures of two examples of SCCPs

Material and methods

Sample collection

A survey was conducted to preliminarily determine the consumer products or articles that are in current use or end of life that may contain PCNs and SCCPs before sample collection was undertaken. For the sample collection strategy the Stockholm Convention inventory guidance documents for PCNs and SCCPs were consulted. The overall aim is to Consumer products samples were obtained from suspected areas where PCNs and SCCPs containing consumer products may be in used. In this first phase of the

X-ray fluorescence (XRF) product testing

Accessible consumer products: sealants, polyvinyl chloride (PVC) cable insulation, plugs and pipes at Tshwane University of Technology, Arcadia campus were subjected to XRF (Olympus Innov-X DELTA XRF analyser) to identify and measure chlorine concentration which may indicate the presence of chlorinated additives in the consumer products. Prior to use, XRF was calibrated using calibration check (pass/fail) 316 stainless steel coupon, followed by the measurement of polymeric check standards (ERM-EC680 and- EC681) through the Mylar window of the plastic cup. The instrument was triggered for 120 s in order to verify the instrument's reliability and accuracy. XRF in the RoHS/WEEE mode triggered for 60 s during each measurement was used to measure chlorine contents of a randomly selected 21 items of consumer products.

Development of PCN and SCCP analysis

For the verification and quantification of PCNs and SCCPs an instrumental analysis needed to be developed. For this PCN standards were purchased from (Wellington Laboratory). For the analysis proven standard methods were chosen and the methods are currently established.

Results and discussion

X-ray fluorescence analysis (XRF) is a quick and easy to use tool that can be employed to qualitatively measure different elements in soil, rocks and ores[14] s been further extended to the screening of elements contained in different consumer products[15]. The XRF results were used as an indicator of the occurrence of PCNs, PCBs, SCCPs or other chlorinated paraffins like medium-chain CPs (MCCPs) or long chain CPs (LCCPs)in various screened consumer products from the laboratory environment (Figure 3).

For products like rubber, sealants or leather, a high chlorine content of several percent is indicative for a chlorinated additive. On the other hand PVC already contains high content of chlorine depending on the additives used. The concentration of chlorine in rigid PVC without plasticiser additives are above 50% while soft PVC contain 50% or more additives and therefore the chlorine content is normally below 30%.

In the screened sealants a high chlorine concentration of 29.79 % was detected indicating that chlorinated additives are present. The University was built 1970s and therefore all additives (PCB, PCN or SCCP) could have been used at that time and further instrumental analysis is necessary.

For PVC rigid PVC contain normally no softeners and flame retardants and have a chlorine content above 50% chlorine. Soft PVC contain frequently 50% of softeners often non-chlorinated phthalates and therefore a chlorine content of less than 30%. SCCPs (or other CP mixtures potentially contaminated with SCCPs[2]) are used as plasticizer or flame retardant in soft PVC with a concentration of up to 15%. Therefore they might add approx. 8% of chlorine to soft PVC. Therefore in the screening of PVC such soft PVC containing SCCPs might have a higher chlorine content compared to soft PVC containing only non-chlorinated plasticizer. Therefore also a range of PVC samples were screened with XRF for chlorine content.

From the PVC samples a blue PVC pipes showed the highest concentration of chlorine 55 % as expected for a rigid PVC material. The concentrations of chlorine in soft PVC like plugs and cables insulators were within the range of 25.89 % to 23.70 %. More screening of soft PVC products and respective analysis of additives need to be performed to see if a chlorine content might be used as indication for a chlorinated additive.

Consumer products with chlorine concentrations of less than 1% are not included in the further assessment by instrumental analysis.

Work is underway to screen more consumer products.

Also the development of a standard method for analysis of PCNs and SCCPs by GC-MS to confirm quantitatively the presence of PCNs, SCCPs or PCBs. The method for PCBs has already been established.
For quality assurance the selected samples analysed positive for SCCPs or PCNs will be sent to the Japanese national laboratory of National Institute of Environmental Studies. This institute has developed a standard analysis for PCNs and SCCPs and is planning a inter-laboratory comparison of industrial POPs in products/waste including PCNs and SCCPs.

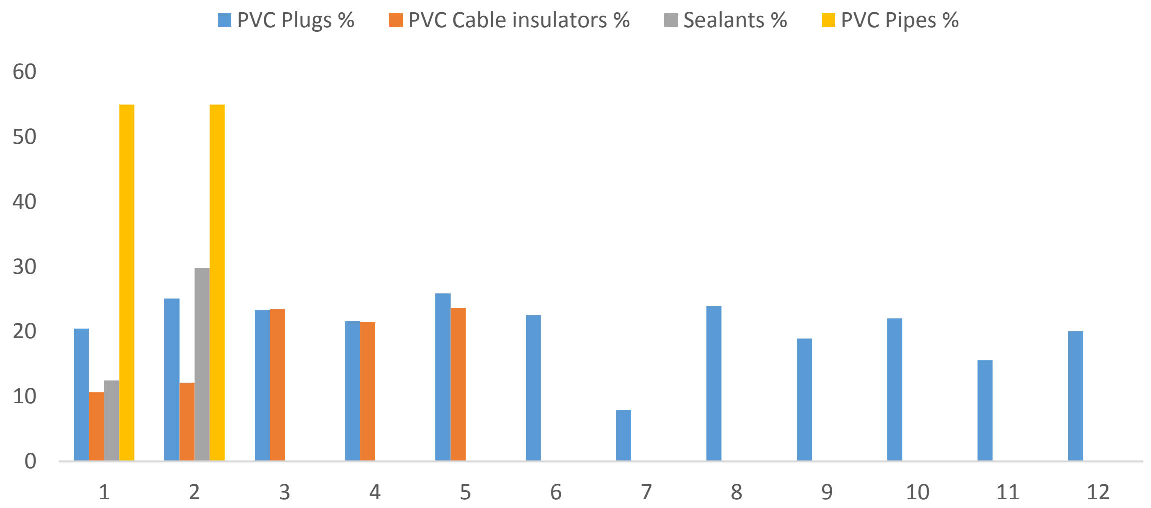

Figure 3**.** Concentrations of chlorine in selected consumer products

Acknowledgements
We would like to acknowledge the support from Tshwane University of Technology and the support from the Stockholm Convention Secretariat and related funding from the European Union.

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Annex 5: Draft TOR for the scientific group supporting initial inventory activities[16]

Draft TORs to develop an initial inventory of the presence of PCNs, PCBs in open application and SCCPs in major products, wastes and recycling

1. BACKGROUND

The Stockholm Convention on Persistent Organic Pollutants is a global treaty to protect human health and the environment from chemicals that remain intact in the environment for long periods, become widely distributed geographically, accumulate in the fatty tissue of humans and wildlife, and have harmful impacts on human health or on the environment. In response to this global problem, the Stockholm Convention, which was adopted in 2001 and entered into force in 2004, requires its parties to take measures to eliminate or reduce the release of POPs into the environment. As set out in Article 1 of the convention, the primary objective of the Stockholm Convention is to protect human health and the environment from persistent organic pollutants.

In May 2015, by decision SC-7/14, the Conference of the Parties amended Annex A to the Convention to list polychlorinated naphthalenes (dichlorinated naphthalenes to octachlorinated naphthalene, referred to as PCNs). PCNs were listed with specific exemptions for production of those chemicals as intermediates in production of polyfluorinated naphthalenes, including octafluoronaphthalene, and the use of those chemicals for the production of polyfluorinated naphthalenes, including octafluoronaphthalene. PCNs were also listed as unintentional POPs in Annex C to the Convention.

In May 2017, by decision SC-8/11, the Conference of the Parties amended Annex A to the Convention to list short-chain chlorinated paraffins (SCCPs) with various specific exemptions. Parties to the Convention for which the amendments to list PCNs and SCCPs have entered into force shall meet the obligations under the Convention leading to the elimination of those chemicals. According to Article 7 of the Convention, each Party shall develop a national implementation plan (NIP) within two years from the date of entry into force. The establishment of inventories is one of the important phases in the development of NIPs. Furthermore, Article 6, paragraph 1 (a), of the Stockholm Convention requires each Party to develop appropriate strategies for the identification of products and articles in use and wastes consisting of, containing or contaminated with POPs.

A guidance on preparing inventories of polychlorinated naphthalenes (PCNs) has been developed by the Secretariat of the Stockholm Convention in 2017 (UNEP 2017a)[17]. It also contains information on PCBs in open application.

The main use of PCNs were practically identical to the uses of PCBs in closed applications (e.g. capacitors, transformers) and open applications (e.g. sealants, paints/coatings). Therefore, the inventory of PCNs should be linked or combined with the PCB inventory. Only a few measurements on PCNs in open applications have been published (e.g. Neoprene FT

[16] For the final report the references were updated in respect to the new guidance documents developed (e.g. PCN guidance draft 2017). These were not mentioned in the original TOR and provided during project.

[17] Please note: PCN guidance has been revised in April 2019 (UNEP 2019a). A draft inventory guidance for SCCPs and a detailed inventory guidance are available since 2019 (UNEP 2019c,b).

Yamashita et al. 2003) and there are no data on PCNs in closed applications other than in PCB oils (Yamashita et al. 2000).
SCCPs together with medium- and long-chain chlorinated paraffins (MCCPs and LCCPs) have substituted PCBs and PCNs in a range of open applications (sealants, paints/coatings, cutting oils). Therefore, the inventory of SCCPs should also be linked or combined with the inventory PCBs and PCNs.
The total global production volume of chlorinated paraffins is more than 1 million tonnes per year (Glüge et al. 2016). It is estimated that still about 165,000 t of SCCPs are produced/used (Glüge et al. 2016). The use of SCCPs in open applications such as PVC/plastic additives, rubber additives, paints, sealants, leather fatliquoring, lubricants and metal working fluids are listed as specific exemptions. These are also the major historic uses and therefore stockpiles and wastes have been accumulated from these and possibly other uses over time.
SCCPs (chain length C10 to C13) can be present in MCCPs (C14 to C18) as impurities. If the SCCP content in MCCPs is above 1%, this mixture is considered as a POP. Therefore, MCCPs should also be analysed and assessed when developing the inventory for SCCPs. SCCP and in higher levels MCCP were recently detected at high levels in backing ovens (Gallistl et al. 2018) and kitchen blenders (Yuan et al 2017). In these studies it was not clarified if SCCPs were impurities of MCCPs or if they were independently applied.
It is important to integrate researchers' groups or governmental institutions with analytical capacity in the development and implementation of the NIP. For example, to identify and manage PCBs in open applications, PCNs and SCCPs (including SCCPs in MCCPs), monitoring and analysis are essential.
Screening, monitoring and a strategic use of research/monitoring capacity to assess and understand the presence of PCNs, together with PCBs in open application and SCCPs in different uses, waste and recycling flows are needed.
For the initial inventory of the current situation of PCNs/PCBs in open application and SCCPs in the country, an initial assessment needs to be conducted. Also the presence of PCNs in closed applications should be assessed within the PCB assessment in transformers and capacitors. At the same time, the draft inventory guidance on PCNs should be tested and evaluated.

2. SCOPE OF WORK, RESPONSIBILITIES AND DESCRIPTION OF THE PROPOSED REPORT WORK

The task for the research group is to gather information and data for the development of a preliminary inventory of PCNs, PCBs in open applications and SCCPs in selected applications. Another objective is to compile current information gaps and respective monitoring needs. An initial collection of relevant samples is carried out and analysis of selected samples for PCBs, PCNs and SCCPs/MCCPs will be realised to the extent feasible.
During the activities, the current situation of the management of materials potentially containing PCNs, PCBs and SCCPs should be briefly described. All activities will be conducted with online-support of Roland Weber.
For the activities, the respective inventory guidances, technical guidelines and other materials supporting inventory development should be considered such as:

- The Stockholm Convention guidance on preparing inventories of polychlorinated naphthalenes (PCNs) (UNEP 2017a).

http://chm.pops.int/Implementation/NationalImplementationPlans/Guidance/tabid/7730/Default.aspx

- Presentations from the regional workshop introducing the links between PCNs, PCBs and SCCPs (will be provided).[18]
- Basel Convention Technical Guidelines on PCBs, PCTs and PCNs (UNEP 2017)[19]
- Further useful literature reviews on SCCPs and MCCPs (will be provided).

The detailed duties of the consultant/research group will include, but will not be limited to, the following specific responsibilities:

- Define the detailed objectives and scope of a (preliminary) qualitative inventory on PCNs, SCCPs and PCBs in open applications in the country considering the objectives and scope setting proposed in the inventory guidance for PCNs, in close communication with Dr. Weber.

  1) Open applications (see chapters of the PCN inventory guidance)
     a) PVC cables and recycled PVC (PCN, SCCP, PCB)
     b) Paints/coatings e.g. ships[20], swimming pools (PCN, SCCP, PCB)
     c) Sealants/caulks and putty (PCN, SCCP, PCB)
     d) Rubber (Chloroprene and other rubber) (PCN, SCCP, PCB)
     e) (Waste) Oils (see 2) below)

     Representative samples should be gathered and analysed as time and capacity allow. The selection of samples should be discussed with Dr. Weber. A list of samples should be compiled, and those samples which cannot be analysed in the first phase, could be analysed in a next phase of the assessment.

  2) Closed applications (See chapters of the PCN inventory guidance)
     a) Propose an approach for integrating PCN monitoring in ongoing or planned PCB monitoring
     b) If feasible, collect samples of mixed waste oils from sectors with possible impact by PCNs and SCCPs.

  3) Initial assessment of potential generation of unintentional PCNs in the country (see Chapter 7 of the PCN inventory guidance)
     a) Identify which of the sources might be present in the country
     b) Compile initial information

  4) Summarize initial findings on potentially PCN (if possible also SCCP) contaminated sites (Chapter 3.4 of the PCN inventory guidance)
     a) Assess which of the potentially PCN contaminated sites might be present in the country. Analogous compilation of SCCP contaminated sites along the lifecycle of production, use in industry/products and end of life

[18] As soon as they were available also the Stockholm Convention detailed guidance on preparing inventories of short-chain chlorinated paraffins (SCCPs) and the short guidance was provided (UNEP 2019a,b)). http://chm.pops.int/Implementation/NationalImplementationPlans/Guidance/tabid/7730/Default.aspx

[19] UNEP (2017c) Technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with polychlorinated biphenyls, polychlorinated terphenyls, polychlorinated naphthalenes or polybrominated biphenyls including hexabromobiphenyl. UNEP/CHW.13/6/Add.4.

[20] The removal of ship paints can generate large wastes of sand blasted paints.

b) If feasible, prepare an initial description of some of these sites

5) Evaluate and provide comments on the PCN inventory guidance (UNEP 2017a)
   a) Is the background information appropriate? What is missing? Suggestion for modification and additions or shortening?
   b) Are the chapters on inventory development appropriately structured and clear? Do you have suggestions for additions, modifications or shortening?

For addressing the above points:

- Develop a work plan on the above listed activities and revise it based on comments received from Dr. Weber and Stockholm Convention Secretariat.
- In cooperation with Dr. Weber, prepare a report:
  - On findings of the assessment of the presence of products, wastes and recycling of materials potentially containing PCNs/PCBs and/or SCCPs (considering chapter 3.2 of the PCN inventory guidance).
  - Compile a list of potentially contaminated sites/hot spots of PCNs/PCBs[21] (and SCCP) considering chapter the PCN inventory guidelines.
  - Conduct a gap analysis and assess the need of future screening and monitoring of PCNs/PCBs and SCCPs in the country.
- Develop a list of sampling and analysis necessary for identifying the presence of PCNs/PCBs and SCCPs in products, wastes and recycling. Prioritize samples for assessment. Conduct initial screening, sampling and analysis to the extent feasible.
- Provide comments on the PCN inventory guidance.

3. Deliverables

Item	%age	Deadline for deliverable
Work plan/methodology submission and approval of the assignment.	5%	Within 1 week of assignment
Report on information and data collection from identified sectors/areas of POPs (PCNs/PCBs, and SCCPs) in products, wastes, recycling and contaminated sites including gap analysis.	40%	Within 12 weeks of the assignment
List of samples and analysis which would be necessary to identify the presence and amount of PCNs/PCBs and SCCPs in products, wastes and recycling. Results from initial screening, sampling and analysis of selected samples.	40%	Within 15 weeks of the assignment
Comments and suggestions to improve the Stockholm Convention PCN inventory guidance	15%	Within 15 weeks of the assignment

4. REQUIREMENTS FOR EXPERIENCE AND QUALIFICATIONS

[21] Since the use of technical PCNs mixtures were in the same use as the PCBs and are unintentionally formed in the same processes as PCBs, the PCB contaminated sites possibly compiled in the NIP could be used as first indication for potentially PCN contaminated sites.

- University Degree in Chemistry, Environmental Science/Engineering, or other relevant discipline.
- At-least five (05) years of professional work experience in related areas of the project including POPs analysis, inventory & management, Stockholm Convention on POPs, hazardous chemicals & waste, environmental management, programme evaluation and coordination.
- Scientific knowledge and good understanding of the national environmental/ developmental technical issues related to POPs and hazardous chemicals & waste.
- Previous work experience with international agencies/ projects is an asset.

Functional Competencies:

- Advanced computer skills in Excel, Word processing, Database management
- Excellent report writing skills;
- Knowledge of research designs are desirable;
- Excellent communication and writing skills both verbal and written in English (Knowledge of local languages will be an additional asset).

References

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UNEP (2019b) Detailed guidance on preparing inventories of short-chain chlorinated paraffins (SCCPs). (Draft of 2019). Secretariat of the Basel, Rotterdam and Stockholm Conventions, United Nations Environment Programme, Geneva. UNEP-POPS-COP.9-SCCP-Revised-2019.[23]

UNEP (2019c) Preliminary draft guidance on preparing inventories of short-chain chlorinated paraffins (SCCPs). UNEP/POPS/COP.9/INF/19. Secretariat of the Basel, Rotterdam and Stockholm conventions, United Nations Environment Programme, Geneva.[23]

Yamashita N, Kannan K, Imagawa T, Miyazaki A, Giesy J P (2000) Concentrations and Profiles of Polychlorinated Naphthalene Congeners in Eighteen Technical Polychlorinated Biphenyl Preparations. Environ. Sci. Technol. 34, 4236-4241.

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Yuan B, Strid A, Darnerud PO, de Wit CA, Nyström J, Bergman Å (2017) Chlorinated paraffins leaking from hand blenders can lead to significant human exposures. Environ Int. 109, 73-80.

[22] During the project BRS Secretariat developed UNEP (2019a) Guidance on preparing inventories of polychlorinated naphthalenes (PCNs). Secretariat of the Basel, Rotterdam and Stockholm Conventions, United Nations Environment Programme. (Revised April 2019.) UNEP/POPS/COP.8/INF/19 (revised 2019)

[23] During the project the SCCP inventory guidance document were developed and forwarded.