environmental affairs

Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

DEVELOPMENT OF NATIONAL INVENTORY FOR TEN NEW PERSISTENT ORGANIC POLLUTANTS (POPs) IN SOUTH AFRICA

FINAL REPORT

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18th December, 2013

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EXECUTIVE SUMMARY

1.1 Introduction

With the Stockholm Convention on Persistent Organic Pollutants in place, the South African government through the Department of Environmental Affairs is obligated to address the inventory of the ten new POPs. To address this, the Department of Environmental Affairs called for proposals to develop National Inventory on ten new POPs in South Africa. The current report focuses on the results obtained by AJUA Evironmental Consultants CC as from February to December 2013on the listed POP chemicals.

1.2 Objectives of the study

The main objective of the current was to:

- Collate information on the quantities of listed POP chemicals and products containing POP-PBDE using the Tier I (initial assessment) approach and from the quantities obtained, determine the POP- PBDE present in the product(s).

1.3 Scope

The scope of this project was to:

Develop a national inventory for ten newly Stockholm Convention listed POPs;

- prepare a comprehensive plan of work which will set out detailed activities, specific outputs as well as dates, resource allocation and payment schedule;
- Achieve the overall and immediate objectives of the inventory and the deliverables as stipulated in the Terms of Reference;
- Identify industries that are potential stakeholders of the required information, and outline the criteria used for the selection of these industries;
- Utilize where available the UNEP toolkit and guidance document of relevance to subject matter to facilitate development of the national inventory for ten new POPs. In cases where the UNEP guidance document provides templates, the service provider was supposed to adopt these and customize to suit the local situation; and
- Conduct a workshop/s with the assistance of DEA to introduce the project outcomes and to obtain support and co-operation from the industry potentially having this information when the project is underway.

1.3 Methodology

The Tier I and Tier II approaches were used to collate the information presented in the current report. Telephone calls and emails were used to contact stakeholders to provide information on the ten new POPs (Appendix B).

POP-PBDE in electronic and electrical products (TV, PC, ICT and refrigerators) imported into South Africa in 2000-2012, was determined using equations in the UNEP POPs-guidance document for inventory of POP-PBDE. Emphasis is on c-OctaBDE since this was used specifically in electronics and electrical equipment.

Sediment and leachate samples (summer and winter) were collected from landfill sites in Pretoria and Johannesburg (Chloorkop, Garskloof, Hatherly, Onderstepoort, Robinson deep and Soshanguve) and analysed for PBDEs in order to ascertain whether these sites can be regarded as contaminated. The selection of the landfill sites was based predominantly on the generation of leachate potential and accessibility. Gas chromatography-Mass Spectrometry (GC-MS) was used for the analysis of POP-PBDEs.

1.4 Results

Global reviews show the extensive use of POP chemicals, particularly PBDEs, lindane, endosulfan, PFOS and its related salts. The Agro-Chemical Industry in South Africa is well developed and has used large quantities of POP chemicals for the the protection of crops. Some of the POP chemicals particularly pesticides (Lindane and Endosulfan) appear to have been withdrawn for agricultural applications, however, some of these are still being imported maybe for other non-agricultural uses. Furthermore, the chemical industry in South Africa consumes large amounts of PFOS and its related salts.

There are legal framesworks in South Africa that are currently used for the management of chemicals. The Hazardus Chemicals Act appears to be adequate to control the newly listed POP chemicals in the absence of specific legislation on POP chemicals.Some management measures have been undertaken by both the public and private sectors for current and future management of POP chemicals in the South Africa's industries.

Tier I and II methods were found to be adequate for the current inventory. However, Tier III approach was used for quantification of PBDEs in identified contaminated sites, despite the fact that it was not part of the scope of the inventory.

The POP-PBDE was determined in electronic and electrical equipment (TV, PC, ICT and refrigerators) imported into South Africa in 2000-2012. Emphasis is on c-OctaBDE since this was used specifically in electronics and electrical equipment. The Σc-OctaBDE for hexaBDE, heptaBDE and octaBDE present in televisions range from 0.0083-0.9949 kg, 0.0323-3.8893 kg and 0.0263-3.1657 kg respectively for 2000-2012. The years 2007 and 2012 exhibited the highest and lowest ΣPOP-PBDE (total/year) respectively. For personal computers, the Σc-OctaBDE for hexaBDE, heptaBDE and octaBDE calculated range from 0.3792-4.7170 kg, 1.4822-18.439 kg and 1.2064-15.009 kg respectively for 2000-2012; while 2004 and 2003 show the highest and lowest ΣPOP-PBDE (total/year) of 38.165 kg and 3.068 kg respectively. In the case of ICT, the Σc-OctaBDE for hexaBDE, heptaBDE and octaBDE range from 158.82-3,296.5 kg, 620.85-12,886 kg and 505.34-10,489 kg respectively. The highest ΣPOP-PBDE (total/year) was recorded for 2012 with a value of 26,671.5 kg and 1284.37 kg recorded for 2002. The Σc-OctaBDE in refrigerators was distributed as follows: hexBDE (2.266-328.13 kg); heptaBDE (8.859-1,007 kg) and octaBDE (7.21-1,044.1 kg). The year 2003 showed the lowest ΣPOP-PBDE (total/year) with a value of 18.366 kg and the highest value of 2,654.9 kg for the 2011. Of all the electronic and electrical equipment, ICT electronics recorded the highest c-OctaBDE with the highest value of 7,031.95 kg. This is followed by refrigerators with the highest value of 2,057.99 kg. The highest recorded c-OctaBDE in personal computers (CRT) and televisions (CRT) are 38.17 kg and 8.049 kg respectively. The highest c-OctaBDE in electronic and electrical equipment is recorded for the following years: 2007 (TV); 2004 (PC); 2006 (ICT) and 2011 (refrigerators).

In the sediment samples from Hatherly and Soshanguve landfill sites, all the PBDEs were detected in all the sites except PBDE-183 in Soshanguve as can be seen in Figure 6-1. PBDE-47 exhibited the highest concentration of 0.54 ng g^{-1}. This was followed by PBDE-99 and PBDE154 with concentrations of 0.25 ng g^{-1}. The PBDEs levels observed for Hatherly site was generally higher than the values for Soshanguve. The detection of PBDE-17, PBDE-47, PBDE-99 and PBDE-153 in all the samples indicated that these were the most common BFRs in the samples analysed. One could, therefore, suggest that these congeners can be used as preliminary screening indicators of BFRs contamination in environmental matrices. PBDE-47, 99, 100, 153, 154, 183 and 209 were all detected from the landfill sites sampled. The highest value (4.2 ng g^{-1}) was recorded for PBDE 209 from Garkloof (Figure 6-2). This was followed by PBDE-153 from Robinson deep (3.8 ng g^{-1}).

Garskloof landfill site is one of the oldest landfill sites within the City of Tshwane Metropolitan Municipality and handles about 45, 000 ton/month of building, garden and household wastes. Large volume and different types of waste dumped into Garskloof may have contributed to the observed high values. PBDE 209 was the highest in Onderstepoort landfill site. Hatherly showed the lowest least BDE values compared to other sites.

PBDE-47 exhibited the highest concentrations in Hatherly and Soshanguve landfill sites. The order for the other congeners was as follows: BDE-153> BDE-99>154>100.17>183. BDE-209 was not detected in leachate samples from either of the landfill sites.

PBDE-47, 99, 100, 153, 154, 183 and 209 were all detected in the leachate samples. PBDE-209 was the highest overall concentration of 1.9 ng g^{-1} for Chloorkop. This was followed by BDE-100 with a concentration of 1.32 ng g^{-1}. BDE-47 was detected at a concentration level of 0.98 ng g^{-1} from Chloorkop and this was followed by BDE209 (0.51 ng g-1) for Robinson deep. The values recorded for winter leachates samples were significantly higher than BDE levels recorded for summer samples.

Large quantities of possible brominated ethers POPs were imported into South Africa in 2007-2011. From the quantities, it is extremely difficult to ascribe any quantity to PBDEs or PFOS. However, a total of 1, 776, 263 kg, 263 990 kg and 71, 478 kg is recorded for categories A, B and C respectively.

Of all the imported POPs chemicals in 2010-2013, PFOS imported into South Africa increased from <5, 000 kg in 2010 to 15, 000 kg in 2011, 20, 000 kg in 2012 and 25, 000 kg in 2013. A significant increase (10, 000 kg) occurred in 2010-2011 and, thereafter, a steady increase of 5, 000 kg $year^{-1}$ was observed. A steady decline in the importation of PFOSF occurred in 2011-2013. The quantities of c-PentaBDE imported were <1000 kg in 2011, 2012 and 2013 and far less than 1000 kg in 2010. The import trend with c-PentaBDE, although increased marginally in 2010-2011, remained the same in 2011-2013. With respect to TetraBDE and chlordecone, quantities far less than 1000 kg was recorded in 2011-2012 and none in 2010 and 2013. PFOS accounted for a total of 93.87%; while others (PFOSF, PeCB, PentaBDE, TetraBDE, β-HCH and chlordecone) accounted for 6.13%.

With respect to exported POPs chemicals, 5,000 kg was recorded for PFOS in 2010 and later peaked up at 22, 000 kg in 2011 and declined to 10, 000 kg in 2012 and finally 8, 000 kg in 2013. The second highest POPs chemical was β-hexachlorocyclohexane with a value of 10, 000 kg in 2012. PFOSF was the third highest POP chemical with a value of 5, 000 kg in 2011 and, thereafter, declined to 2, 500 kg in 2012 and <2, 000 kg in 2013. β-HCH and others

(PeCB, PentaBDE, TetraBDE, and chlordecone) accounted for 77.61%, 16.59% and 5.80% respectively.

The total quantities (kg) of PFOS imported and exported into and out of South Africa in 2010-2013 amounted to 72,333 kg and 67,720 kg respectively. PFOS imported into South Africa increased from <5, 000 kg in 2010 to 15, 000 kg in 2011, 20, 000 kg in 2012 and 25, 000 kg in 2013. A significant increase (10, 000 kg) occurred in 2010-2011 and, thereafter, a steady increase of 5, 000 kg/year was observed. The observed increase in PFOS imported into South Africa is an indication of the demand for the chemical. However, the quantities of PFOS exported from South Africa was about 5, 000 kg in 2010, increased dramatically in 2011 to 23, 000 kg and, thereafter, declined to 10, 000 kg in 2012 and finally about 8, 000 kg in 2013.

The total quantity of PFOSF imported into South Africa was 3, 024 kg. The quantity of PFOSF imported in 2010 was <2, 000 kg and since then has been on the decline. A steady decline in the importation of PFOSF occurred in 2011-2013. However, the quantity exported in 2011 amounted to about 5, 000 kg, although this has declined to <2, 000 kg in 2013.

Most of the companies contacted during the survey indicated that fire extinguishers containing PFOS were phased out 10 years ago. Most of the companies in the fire industries indicated that they were their formulations from chemical giants such as Chemserve. Material datasheets indicated that chemicals used in fire extinguishers currently in South Africa do not contain PFOS.

The quantities of β-HCH imported into South Africa from 2011-2013 remained the same at <1, 000 kg. However, a different pattern was observed for the export whereby the quantity exported peaked at 10, 000 kg in 2012. Little or no importation was observed in 2010, 2011 and 2013. A total of 10, 000 kg were exported to the Democratic Republic of Congo (DRC). Quantities for import were not given. This probably suggests that stock β-HCH from previous years may have accounted for the observed increase in export or that the chemical is produced in South Africa.

No values were obtained for the importation of PeCB for the period 2011-2013. However, a total amount of 1, 500 kg was exported.

A total of 1, 273 kg was imported into South Africa from China and the United Kingdom. The amount imported from China accounted for 88%; while that from the United Kingdom accounted for only 12%. No export values were given.

A total of 131 kg of TetraBDE was imported into South Africa from Germany and the United Kingdom, while 750 kg was exported to Peru in 2012. Again, the amount imported was by far less than the amount exported.

Only 4 kg was recorded for the total amount of chlordecone imported into South Africa from the United Kingdom in 2010-2013.

Of all the imported POPs chemicals in 2010-2013, PFOS accounted for a total of 93.87%; while others (PFOSF, PeCB, PentaBDE, TetraBDE, β-HCH and chlordecone) accounted for 6.13%. With respect to exported POPs chemicals, PFOS, β-HCH and others (PeCB, PentaBDE, TetraBDE, and chlordecone) accounted for 77.61%, 16.59% and 5.80% respectively.

Large quantities of PFOS and related salts were imported mainly from Europe and POP chemical exports from South Africa were mainly to African countries.

Large quantities of lindane and pentachlorobenzene and its derivatives were imported into South Africa in 1988-2011. The quantities of lindane and pentachlorobenzene and their derivatives imported into South Africa peaked in 1996 and 1995 in the region of 1, 075, 460 kg and 2,962,999 kg respectively. Thereafter, the quantities of lindane imported into South Africa decreased drastically in 2008 and appears to be on the rise up to 2010. The total quantities of lindane and pentachlorobenzene and its derivatives imported into South Africa in 1988-2011 came to 1, 409, 695 kg and 24, 678, 541 kg respectively.

The quantities of endosulfan and lindane ranged from 0.02-175 kg and 0.02-500 kg respectively. Clanwilliam and Stellenbosch recorded the highest and lowest quantities of 175 kg and 0.02 kg) respectively. In the case of lindane the highest (500 kg) and lowest (0.02 kg) quantities were recorded for De Aar and Stellenbosch respectively. Quantities of endosulfan from other areas include: 35 kg (Bethlehem); 10 kg (Franchhoek); 25 kg (Heilbron); 25 kg (Kaapse Wynland); 30 kg (Kaapstad); 25 kg (Koelenhof); 2 kg (Marble Hall); 20 kg (Riversonderend); 3 kg (Robbertson); 5 kg (Somerset Wes) and 20 kg (Wellington). With respect to lindane, the following quantities were recorded: 1-5 kg (Bethlehem) and 0.15 kg (Potchefstroom). Stellenbosch recorded 0.02 kg of γ-HCH.

Generally, endosulfan was widely applied to maize to prevent pesticides such as stock-borers and armyworms. The quantities of endosulfan applied to maize decreased from 128,744 L in 2006 to 3840 L in 2012, indicating 97% decrease. By 2012, application of endosulfan in maize crops was still the dominant consumption of endosulfan in South Africa. The second largest consumer of endosulfan was fruity crops and others.

1.5 Conclusion

The current study has been able to show that:

- Quantities of POP-PBDEs in various EEE and WEEE products were determined;
- Σc-OctaBDE in stock, stock entering into the waste stream and polymer fractions (recycling) were calculated;
- The order of Σc-OctaBDE in electronic and electrical equipment were: ICT>refridgerators>PC>TV;
- Σc-OctaBDE and Σc-PentaBDE in imported cars into South Africa from the USA and other regions in 2000-2005 were also determined;
- Analysis of leachate and sediment samples from six landfill sites showed the presence of PBDEs and, therefore, these sites can be confirmed to be contaminated with one of the ten new POP chemicals, PBDEs;
- Large quantities of POP-PBDE are imported into South Africa;
- PFOS accounted for more than 90% of POP chemicals imported into South Africa;
- Verification of data was done by comparing the data obtained from UNcomtrade and **the dti**.
- Of the six pesticides listed, five have been prohibited in South Africa;
- Only pentachlorobenzene and its derivatives appeared not to have been prohibited since no information was available to indicate so;
- Despite the fact that registration of a number of pesticides have been withdrawn years ago, they were still being imported and exported into and from South Africa to date.

1.6 Gaps

The gaps observed in the current inventory includes, but not limited to the following:

- Information on the applications of PFOS to industrial products was not available;
- Legal document on the banning of some POP chemicals was also not avalable;
- Small scale EEE and WEE recyclers was not accounted in the case of POP-PBDE in EEE casting for polymer;
- Information on contaminated sites is still scanty and, therefore, there is need for more in-depth inventory;
- Specific legislation on POP chemicals was found not to be available, although the Hazardous Chemical Act can suffice for now;
- Monitoring of the use, storage and final disposal of POP chemicals should be intensified;
- Accountability and retention of data on POP chemicals need to be improved;

- Communication and exchange of information on POP chemicals within different Government departments need to improve.

1.7 Recommendations

- There was enough evidence to show that a number of the POP chemicals listed under the Stockholm Convention have been used in South Africa to date. There is, therefore, an urgent need to have some regulations to restrict/ban the use of POP chemicals in the country;

- To account for unused POPs chemicals, importers and formulators of these pesticides should give accurate account of the unused chemicals in their possession before renewal of their licenses;

- There is a need to intensify the monitoring of POP chemicals in use and obsolete and their specific applications and

- There are several alternative chemicals to the newly listed POPs chemicals and the use of these alternatives should be encouraged.

1.8 ABBREVIATIONS

AVCASA	Association of Veterinary and Crop Associations of South Africa
BFRs	Brominated flame retardants
CC	Close corporation
CRT	Cathode Ray tubes
DAFF	Department of Agriculture, Food and Fisheries
DEA	Department of Environmental Affairs
DoH	Department of Health
DoL	Department of Labour
DNA	Designated National Authority
the dti	Department of Trade and Industry
DWA	Department of Water Affairs
GG	Government Gazette
GC-MS	Gas Chromatography-Mass Spectrometry
GN	Government Notices
HCH	Hexachlorohexane
ICT	Information communication Technology
NIP	National Implementation Plan
PBDE	Polybromodiphenyl ether
PC	Personal computers
PentaBDE	Pentabromodiphenyl ether
PFOS	Perfluorooctane sulphonate
PFOSF	Perfluorooctane sulphonate fluoride
POPs	Persistent Organic Pollutants
Statistics SA	Statistics of South Africa
TetraBDE	Tetrabromodiphenyl ether
UNEP	United Nations Environmental Programme
UNFAO	United Nations Food and Agricultural Organization
UNIDO	United Nations Industrial Development Organization
USEPA	United States Environmental Protection Agency
WHO	World Health Organization

CHAPTER 1: BACKGROUND ON PERSISTENT ORGANIC POLLUTANTS (POPs)

1.1 Introduction

Persistent Organic Pollutants (POPs) are a group of chemicals that are widely used in agriculture and industrial practices, as well as unintentionally released from many anthropogenic activities (UNEP, 1999). POPs are persistence and as a result resist degradation in the environment. They have the ability to bio-accumulate in living tissues at levels higher than those in the surrounding environment; and have the potential to travel great distances from the source of release through various media (UNEP, 1999). The ability of these toxic compounds to be transported to isolated areas of the globe such as the Arctic, and to bio-accumulate in food webs has raised concerns for the health of humans and the environment (UNEP, 1999). POPs are ubiquitous and, therefore, have been detected in many environmental matrices (Darnerud et al., 2001; de Boer et al., 2004).

The South African government has recognized chemical hazards as a priority problem, particularly chemicals management under Chapter 19 Agenda 21. In South Africa, the Stockholm Convention is implemented by the South African Government through the Department of Environmental Affairs (DEA), who is the Designated National Agency (DNA), in consultation with various other departments such as Departments of: Agriculture Forestry and Fisheries, Water Affairs, International Relations, Trade and Industries, Science and Technology, Health and Custom and Excise and others. In addition, several non-governmental organisations, industry bodies and parastatal organisations are consulted on the implementation of the Convention through a national chemicals stakeholder coordination committee.

South Africa is a party to three other multilateral agreements which deal with chemicals management issues namely; the Basel Convention on the Control of Trans-boundary Movement of Hazardous Waste, the Rotterdam Convention on the Prior Informed Consent Procedures for Certain Hazardous Chemicals and Pesticides in International Trade, and the Montreal Protocol on Substances that Deplete the Ozone Layer. South Africa also played a leading role in the development of the Strategic Approach to International Chemicals Management (SAICM) and contributes to its Quick Start Programme.

Article 7 of the Stockholm Convention identifies the requirement for each Party to develop and to endeavor to put into practice a plan for the implementation of its obligation under the Convention. The plan is to be integrated into the sustainable development strategies where appropriate and is to be reviewed and updated on a periodic basis. In line with the requirements of the Convention and realizing the need to take the necessary measure to prevent the harmful impacts of POPs, South Africa has developed its National Implementation plan (NIP) with the following expected outcomes:

- protection of South Africans' health from the effect of POPs;
- Promotion of a cleaner South African environment;
- Improvement of South Africa's capacity to manage POPs;
- Reduction of South Africa's contribution to global pollutant loading and
- Contribution to meeting South Africa's commitments under the Stockholm Convention.

The National Implementation Plan needs to be updated in order to include the ten new POPs, hence the call for an inventory of these new POPs.

1.2 Project aim

The overall aim of the project was to:

- obtain sufficient quantitative information base for updating National Implementation Plan (NIP);
- determine baseline situation with regards to new POPs in South Africa; and
- Strengthen national capacity to manage POPs and maximize government commitment to manage POP.

1.3 Scope and limitations

1.3.1 Scope

The scope of tis project was geared towards achieving the following:

- Introduction to the overall POPs situation in the country and the nature of the inventorying of POPs;
- Identify the sectors in which the above chemicals/pesticides are used; the various applications for which these chemicals are used and the criteria used for the identification of these sectors;
- Identify existing national institutional and regulatory measures and regulations governing the regulation, approval, monitoring, import and export and mechanism for banning of POPs;

- Characterisation of procedures for past and present production and/or use of POPs;
- Determination of future measures preventing future production and/or use of POPs Pesticides;
- Determination of previous and present import and export of POPs pesticides;
- Visualise stakeholder responsibilities and asses possibilities for illegal trade;
- Identify the amounts of the various chemicals/pesticides imported into the country and their applications;
- Identify stockpiles of POPs pesticides and POPs waste. Determine relative geographical location, amounts stockpiled;

;

- Identify if there are any existing management initiatives or measures from Government and private sector that are in place to manage the chemicals/pesticides listed above, or any planned initiatives or measures;
- Utilize where available the UNEP toolkit and guidance document of relevance to subject matter to facilitate development of the national inventory for ten new POPs. In cases where the UNEP guidance document provides templates, the service provider needs to adopt these and customize to suit the local situation; and
- Conduct a workshop/s with the assistance of DEA to introduce the project outcomes and to obtain support and co-operation from the industry potentially having additional information to be added to the final project documentation.

1.3.2 Limitations

It was expected that all identified stakeholders would be able to participate in providing the required information for the inventory. However, where this was not possible, data from international database on POPs were used where and when necessary. It is also pertinent to mention that only Tiers I and II methodologies as stipulated in UNEP toolkit were used in this study. However, Tier III was used in the case of contaminated sites, where environmental samples were collected from some landfill sites and analysed in order to confirm contamination of the sites. Furthermore, only the most common POP-PBDE were analysed for in the samples due to availability of standards limitations.

CHAPTER 2: ANALYSIS OF THE GLOBAL SITUATION FOR TEN NEW POPs LISTED UNDER THE STOCKHOLM CONVENTIONS

2.1 Introduction

Persistent organic pesticides (POPs) are considered to be endocrine disrupters, which, by altering the hormonal system, can damage the reproductive and immune systems of exposed individuals as well as their offspring (Colborn and Clement, 1992). In the 1970s, it was discovered that this characteristic of persistence along with a growing body of evidence of their chronic, carcinogenic properties represented a serious threat to human health such as damage to the liver, skin, gastrointestinal track, thyroid gland and the environment (Gray et al., 1996).

2.2 United Nations Convention on POPs

2.2.1 The Stockholm convention

The Stockholm Convention on Persistent Organic Pollutants (POPs) is a global treaty adopted in 2001 and entered into force in 2004 requiring Parties to take measures to eliminate or reduce the production, use, trade, release and storage of POPs. Currently, the Convention covers the production and use of 22 pesticides, industrial chemicals and POPs produced unintentionally as by-products of other processes. As POPs have the potential to be transported between countries, governments agreed that in order to address the threats posed by the trans-boundary movement of these POPs a multilateral approach was required. In May 1995 the Governing Council of the United Nations Environmental Programme (UNEP) requested that an international process be undertaken to assess an initial list of twelve POPs and that recommendations be prepared for consideration by the UNEP Governing Council and the World Health Assembly by 1997. Based on the recommendations made, governments agreed in February 1997 that the most effective approach to managing the threats posed by POPs was a binding international agreement. Negotiations to develop the text for the international legally binding instrument began in June 1998 and were concluded in December 2000 and entered into force in 2004.

South Africa ratified the Convention on the 23rd of May 2001 and became a party on 4 September 2002. As at the 4th of May 2010, 152 countries had signed the convention and 170 countries had ratified and became parties to the Convention. The main objective of the Convention is to protect human health and the environment from POPs by controlling POPs with a view to phase them out. The Convention focuses on three broad areas namely:

- POPs which are intentionally produced and used;
- POPs which are unintentionally produced, and released from anthropogenic sources and
- POPs in stockpiles and wastes.

The Convention requires that each Party prohibit and/or take any legal and administrative actions required for the elimination/reduction of POPs production and use, export and import, as well as to take actions to minimize or prevent POPs releases. The Convention identifies specific POPs for management which are contained in Annexes A, B and C of the Convention. These Annexes include the initial twelve POPs identified in May 1995, the nine new POPs listed in May 2009 as well as the unintentionally produced and released POPs which result from some industrial processes. Management measures for these POPs are contained in specific Articles to the Convention.

At its fourth meeting, the Conference of the Parties (COP) of the Stockholm Convention agreed to list ten (10) new POPs in Annexes A, B, and C of the Convention. One of the immediate actions that Parties needed to undertake was to review and update their National Implementation Plans (NIPs) in the light of the inclusion of these ten new POPs in accordance with paragraph 1 (c) of Article 7 of the Convention. Management measures for these POPs are contained in specific Articles to the Convention. These POPs and their management measures are identified in Table 2-1.

Table 2-1: List of Stockholm Convention 10 new POPs

Chemical	Intentional production and use - Pesticide	Intentional production and use - industrial chemical	Un-intentional production	Application	CAS No	Annex and Management measure
Chlordecone	✓			Pesticide	143-50-0	Annex A – **Elimination**
Endosulfan	√			Pesticide		Annex A -**Elimination**
Hexabromobiphenyl		✓		Industrial chemical	36355-01-8	Annex A – **Elimination**
Heptabromodiphenyl ether		✓		Industrial chemical	various	Annex A – **Elimination** for production, exemption for use as articles containing these chemicals for recycling
Alpha hexachlorocyclohexane	✓		✓	Pesticide	319-84-6	Annex A – **Elimination.** No exemptions Annex C – manage unintentional production
Beta hexachlorocyclohexane	✓		✓	Pesticide	319-85-7	Annex A – **Elimination.** No exemptions Annex C – manage unintentional production

Lindane	✓			Pesticide	58-89-9	Annex -Elimination. No exemptions for production in countries registering exemptions for use as a human health pharmaceutical
Pentachlorobenzene (PeCB)	✓	✓	✓	Pesticide	608-93-5	Annex A – **Elimination** No exemptions Annex C – manage unintentionally produced
Perfluorooctane sulfonic acid (PFOS) its salts & perfluorooctane sulfonyl fluoride (PFOS-F)		✓		Industrial chemical	various	Annex B – phase out with acceptable purpose and specific exemptions
Tetrabromodiphenyl ether		✓		Industrial chemical	various	Annex A – Elimination for production, exemption for use as articles containing these chemicals for recycling
Penta-bromodiphenyl ether		✓		Industrial chemical	various	Annex A – Elimination for production, exemption for use as articles containing these chemicals for recycling

The following sections provide an overview of each of the chemicals listed in Table 2-1 and provide insights into the chemicals and their properties, toxicity and current usage.

2.2.1.1 Chlordecone

Chlordecone is a tan to white crystalline odourless solid (NIOSH, 1978). The structure of chlordecone is shown in Figure 2-1. Chordecone is also known by the following names: Kepone, decachlorooctahydro-1,3,4-metheno-2H-cyclobuta(cd)-pentalen-2-one, and GC-1189 (Metcalf, 2002).

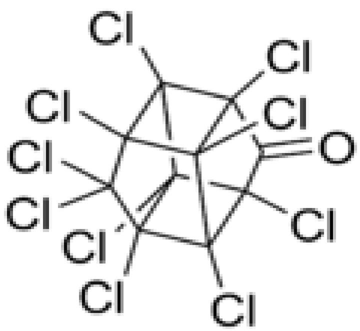

Figure 2-1 Chemical structure of Chlordecone

Approximately 3.6 million ton of chlordecone were produced in the United States between 1951 and 1975 (ATSDR, 1995). Chlordecone production in the United States ended in 1975 after intoxication from severe industrial exposure was observed in employees who worked at the only chlordecone manufacturing plant in the country (USEPA, 2009). Chlordecone was primarily used as an insecticide and specific applications have included control of the banana root borer, non-fruit-bearing citrus trees to control rust mites, control of wireworms in tobacco fields, control of apple scab and powdery mildew, the grass mole cricket, and control of slugs, snails, and fire ants (ATSDR, 1995).

In South Africa, chlordecone was used as a pesticide to control apple scab and powdery mildew and prohibited for use in agriculture in 1973.

Typical signs of chlordecone intoxication include: nervousness, headache, and tremor (Cannon et al., 1978). Chlordecone is resistant to degradation in the environment and has high potential for bioaccumulation in fish and other aquatic organisms (ATSDR, 1995).

2.2.1.2 Endosulfan

Endosulfan is an off-patent organochlorine insecticide and acaricide. It has two isomers namely, endo and exo. It is a derivative of hexachlorocyclopentadiene, and is chemically similar to aldrin, chlordane, and heptachlor. Technical endosulfan is a 7:3 mixture of stereoisomers, designated α and β. It is subject to long-range atmospheric transport, i.e., it can travel long distances from where it is used. Thus, it occurs in many environmental compartments (ATSDR, 2000). The compound has been shown to be one of the most abundant organochlorine pesticides in the global atmosphere (ATSDR, 2000). The chemical structure of endosulfan is shown in Figure 2-2

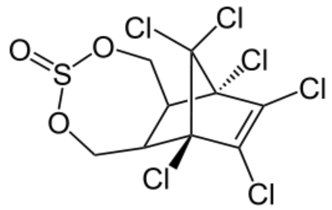

Figure 2-2 Chemical structure of endosulfan

Endosulfan has been used in agriculture around the world to control insect pests including whiteflys, aphids, leafhoppers, Colorado potato beetles and cabbage worms (IPCS, 1984). The annual production was estimated to be about 9,000 metric tonnes (t) in the early 1980s (IPCS, 1984). From 1980-1989, worldwide consumption averaged 10,500 tonnes per year, and for the 1990s use increased to 12,800 tonnes per year (IPCS, 1984).

Endosulfan is an endocrine disruptor, causing reproductive and developmental damage in both animals and humans (Colborn et al., 1993). Because of its threats to human health and the environment, a global ban on the manufacture and use of endosulfan was negotiated under the Stockholm Convention in April 2011. Consequently, endosulfan has been banned in many countries including South Africa. According to Food and Agriculture Organization of United Nations, long-term exposure from food is unlikely to present a public health concern, but short-term exposure can exceed acute reference doses (FAO, 2011).

The use of endosulfan in South Africa has declined tremendously. In 1997, a total of 217,048 tonnes of five different forms of endosulfan was used (TIC, 2010). Use is now only confined to two forms namely, the miscible oil and the soluble concentrate. By 2009, the total volume of endosulfan used was approximately 56,950 tonnes. In 2012, endosulfan was withdrawn for use in South Africa (TIC, 2010).

2.2.1.3 α-Hexachlorocyclohexane

α-Hexachlorocyclohexane (α-HCH) is an organochloride which is one of the isomers of hexachlorocyclohexane (HCH) (ATSDR, 1998). It is a by-product of the production of the insecticide lindane (γ-HCH) and it is typically still contained in commercial grade lindane used as insecticide. At ambient temperatures, it is a stable, white, powdery solid substance. The chemical structure of α-HCH is shown in Figure 2-3.

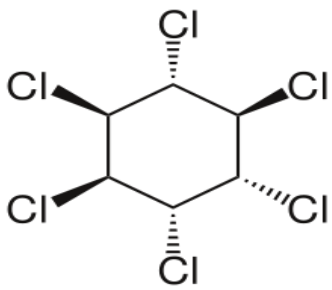

Figure 2-3 Chemical structure of α-Hexachlorocyclohexane

α-HCH allows for long-range transport and it can volatilize due to its vapour pressure and low octanol-air partition coefficient from soil surfaces. It is produced as the main constituent of technical HCH which is used as organochlorine insecticide or chemical intermediate to manufacture enriched HCH (lindane). Consequently, the manufacture of lindane has resulted in a huge amount of HCH residuals. It has been reported that there are stockpiles of approximately 2,785 tons of technical HCH and 45 tons of unspecified HCH material in Africa and the near East (UNEP, 2006c).

Around 10 million tons of technical HCH were released into the environment between 1948 and 1997 (Li, 1999). According to Li and Macdonald (2005), global usage of technical HCH was dominated by 10 countries headed by China, which consumed almost half of the total global quantity. The other countries were: former Soviet Union, India, France, Egypt, Japan, United States, Spain and Mexico (Li, 1999). Usage of technical HCH was banned in most western countries and Japan in the 1970s but continued in China and Russia until 1983 and

1990. Technical HCH usage has steadily declined and now technical HCH is virtually no longer used worldwide. However, there are indications that the use of stockpiles, limited use for public health purposes and/or illegal use cannot be excluded (Breivik et al., 1999).

It has been reported that α-HCH at high dose levels, produces nodular hyperplasia and hepatocellular carcinomas in mice (the incidence varying according on the strain) and also in rats (low incidence). α-HCH has been shown to promote tumors in the liver of mice and rats (IPCS, 1984). The International Agency for Research on Cancer (IARC) classified α-HCH in group 2A: possibly carcinogenic to humans and USEPA categorized α-HCH as probable human carcinogen (USEPA, 2009). Adverse effects such as neurophysiological and neuropsychological disorders and gastrointestinal disturbances have been reported for workers exposed to technical HCH during pesticide or fertilizer formulation (ATSDR, 1998).

2.2.1.4 β-Hexachlorocyclohexane

β-hexachlorocyclohexane (β-HCH) is an organochloride compound which is one of the isomers of hexachlorocyclohexane (HCH). It is a byproduct of the production of the insecticide lindane (γ-HCH). It typically constitutes 5-14% of technical grade lindane (ATSDR, 1998). The chemical structure of β-hexachlorocyclohexane is shown in Figure 2-4.

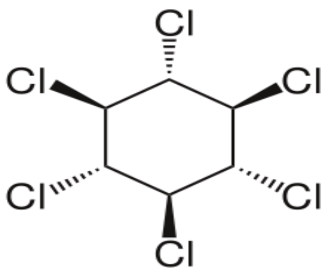

Figure 2-4 Chemical structure of β-hexachlorocyclohexane

β-HCH by itself is neither intentionally produced nor placed on the market. It is produced as constituent of technical HCH used as organochlorine insecticide or chemical intermediate to manufacture enriched HCH (lindane). Technical β-HCH was rapidly introduced in the 1940s on a large scale on the market due to its universal insecticidal properties. Walker et al. (1999) reported stockpiles of approximately 2,785 tons of technical HCH and 45 tons of unspecified HCH material in Africa and the Near East. This pesticide was widely used during the 1960s and 1970s, particularly on cotton plants. Although banned as a pesticide more than 30 years ago, traces of β-HCH can still be found in water and soil.

Breivik et al (1999) estimated technical HCH usage at approximately 400 000 tons technical HCH in Europe alone between 1970 and 1996. According to Li and Macdonald (2005) global usage of technical HCH was dominated by countries such as China, which consumed almost half of the total global quantity. Technical HCH usage steadily declined and is now virtually out of use worldwide. However, there are indications that the use of stockpiles, limited use for public health purposes and/or illegal use cannot be excluded (Li and Macdonald, 2005). In 1980 the usage of β-HCH was around 36 kg tonnes, and the calculated primary emissions were 9.8 kg tonnes (83 % attributed to the application and 17 % to soil residues due to prior applications) (UNEP, 2009). In 1990 figures dropped to 7.4 (usage) and 2.4 thousand tons (emissions) UNEP, 2009). In 2000, emissions of β-HCH from soil residues were 66 tonnes in the absence of direct usage of technical HCH (UNEP, 2009). Releases of beta-HCH into the environment are also possible from hazardous waste sites, stockpiles and residues of lindane production, which are not always controlled or maintained safely (UNEP, 2009). Also, contaminated sites, for example, former production plants may contribute to the environmental burden of β-HCH (ATSDR, 2005). Animal studies show that β-HCH, is a neurotoxic, causes oxidative stress, and damages the brain's dopaminergic system. Human studies show that exposures to β-HCH are linked to Parkinson's and Alzheimer's disease (ATSDR, 2005). The use of β-HCH in South Africa was prohibited in 1987 according to the Registrar of pesticides.

2.2.1.5 Lindane

Lindane, also known as *γ*-hexachlorocyclohexane, (γ-HCH), gammaxene, Gammallin and erroneously known as benzene hexachloride (BHC), is an organochlorine chemical variant of hexachlorocyclohexane that has been used both as an agricultural insecticide and as a pharmaceutical treatment for lice and scabies (Li, 1999). Lindane is a persistent organic pollutant. It is relatively long-lived in the environment and transported long distances by natural processes like global distillation, and it can bioaccumulate in food chains, though it is rapidly eliminated when exposure is discontinued. The chemical structure of lindane is shown in Figure 2-5.

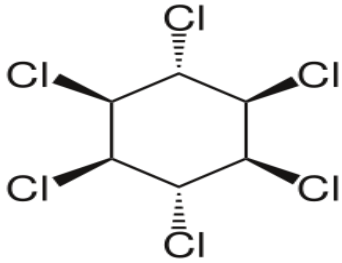

Figure 2-5 Chemical structure of Lindane

Lindane is used as an insecticide on fruit and vegetable crops (including greenhouse vegetables and tobacco), for seed treatment and in forestry. It is also used as a therapeutic pesticide (e.g., in the treatment of scabies) in humans and animals (ATSDR, 1998; IPCS, 1984). It is estimated that between 1950 and 2000, around 600,000 tonnes of lindane were produced globally, and the vast majority of which was used in agriculture. It was manufactured in several countries, including the United States, China, Brazil, and several European countries, but as of 2007 only India and possibly Russia were still producing it (UNEP, 2009d).

The production and agricultural use of lindane are the primary causes of environmental contamination, and levels of lindane in the environment have been decreasing in the U.S., consistent with decreasing agricultural usage patterns (IPCS, 1984). The production of lindane generates large amounts of waste hexachlorocyclohexane isomers, and it is estimated that "every ton of lindane manufactured produces about 9 tons of toxic waste (UNEP, 2009d). When lindane is used in agriculture, an estimated 12-30% of it volatilizes into the atmosphere, where it is subject to long-range transport and can be deposited by rainfall (Li, 1999). Lindane in soil can leach to surface and even groundwater, and can bioaccumulate in the food chain. However, biotransformation and elimination are relatively rapid when exposure is discontinued (Li, 1999).

Most exposure of the general population to lindane has resulted from agricultural uses and the intake of foods, such as produce, meats and milk, produced from treated agricultural commodities. Human exposure has decreased significantly since the cancellation of agricultural uses in 2006 (FAO, 2002; UNEP. 2009c). By 2006, the use of lindane had been banned in 52 countries including South Africa and restricted in 33 others (UNEP, 2009d).

Lindane was toxic to the kidney and liver after administration orally, dermally or by inhalation in short-term and long-term studies of toxicity and studies of reproductive toxicity in rats (ATSDR, 1998).

2.2.1.6 Pentachlorobenzene (PeCB)

Pentachlorobenzene (PeCB) is a chlorinated aromatic hydrocarbon compound. PeCB can be produced as a byproduct of the manufacture of carbon tetrachloride and benzene. Since PeCB is generally produced in small quantities in the chlorination of benzene, it is also contained in other chlorobenzenes such as dichlorobenzenes and trichlorobenzenes, to mention but two. Today, a majority of the PeCB released into the environment is a result of municipal waste incineration (WHO, 1995). The chemical structure of pentachlorobenzene is shown in Figure 2-6.

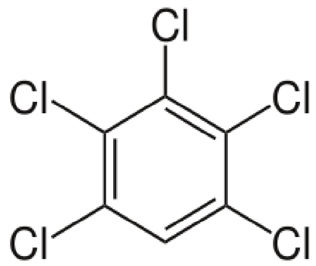

Figure 2-6 Chemical structure of Pentachlorobenzene

PeCB was once used industrially as an intermediate in the manufacture of pesticides, particularly the fungicide pentachloronitrobenzene (WHO, 1995). Pentachloronitrobenzene is now made by the chlorination of nitrobenzene in order to avoid the use of PeCB (WHO, 1995). PeCB has also been used as a fire retardant (WHO, 1995). Short-term exposure to pentachlorobenzene can affect the central nervous system. Longterm exposure can affect the liver and kidneys and can cause tissue lesions. Animal studies and tests show that pentachlorobenzene can possibly cause toxic effects on human reproduction (ATSDR, 1998).
Information on the use of PeCB in South Africa is scarce.

2.2.1.7 Perfluorooctane sulfonic acid (PFOS)

Perfluorooctane sulfonate (PFOS) or perfluorooctanesulfonic acid (PFOSA), is a man-made fluorosurfactant and global pollutant. PFOS was the key ingredient in Scotchgard, a fabric protector and numerous stain repellents and its chemicals structure is shown in Figure 2-7. It was added to Annex B of the Stockholm Convention on Persistent Organic Pollutants in May

2009 (Paul et al., 2009). PFOS can form from the degradation of precursors in addition to industrial production (Paul et al., 2009).

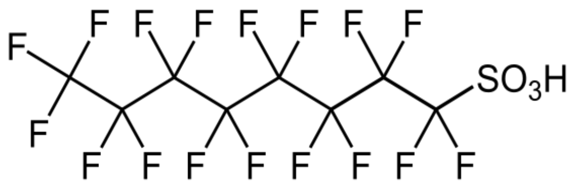

Figure 2-7 Chemical structure of PFOS

The C_8F_{17} subunit of PFOS is hydrophobic and lipophobic, like other fluorocarbons, while the sulphonic acid/sulphonate group adds polarity. PFOS is an exceptionally stable compound in industrial applications and in the environment because of the effect of aggregate carbon–fluorine bonds (OECD, 2005). PFOS is a fluorosurfactant that lowers the surface tension of water more than that of hydrocarbon surfactants. Although attention is typically focused on the straight-chain isomer (n-PFOS), which is dominant in commercial mixtures and environmental samples, there are 89 linear and branched congeners that are expected to have different physical, chemical, and toxicological properties.

In 1949, 3M began producing PFOS-based compounds by electrochemical fluorination resulting in the synthetic precursor perfluorooctane sulphonyl fluoride (OECD, 2005). PFOS was still manufactured in Germany (20–60 tonnes) and Italy (< 22 tonnes) in 2003 (OECD, 2005). The total global production volume today is not known but was estimated to 5,000 tonnes per year in 2000 (UNEP, 2009). The estimated quantity for PFOS-containing fire fighting foams, currently held in stock in the European Union, was 122 tonnes in 2004 (OECD, 2005).

In 1999, the U.S. Environmental Protection Agency began investigating perfluorinated compounds after receiving data on the global distribution and toxicity of PFOS, the key ingredient in Scotchgard (USEPA, 1999). PFOS and PFOS-related chemicals are currently produced in China. PFOS is usually used as the sodium or potassium salts in the following:

- As a key ingredient in Scotchgard, a fabric protector and numerous stain repellents (USEPA, 1999);
- PFOS and PFOA have also been used to make aqueous film forming foam (AFFF), a component of fire-fighting foams, and alcohol-type concentrate foams (OECD, 2005);

- PFOS compounds can also be found in some impregnation agents for textiles, paper, and leather; in wax, polishes, paints, varnishes, and cleaning products for general use; in metal surfaces, and carpets (OECD, 2005);

- In the semiconductor industry, PFOS is used in multiple photolithographic chemicals including: photoacid generators (PAGs) and anti-reflective coatings (ARCs). It has been phased out in the European Union semiconductor industry due to health concerns (OECD, 2005) and

- In Skydrol, a hydraulic fluid used in commercial aviation (OECD, 2005).

In animal studies PFOS also causes cancer, physical development delays, endocrine disruption, and neonatal mortality; neonatal mortality might be the most dramatic result of laboratory animal tests with PFOS (Brook et al., 2004). PFOS levels in pregnant women have been associated with preeclampsia (Brook et al., 2004). Levels have also been associated with altered thyroid hormone values (Berthiaume and Wallace, 2002) and an increased risk of high cholesterol (Brook et al., 2004).

2.2.1.8 **Polybromodiphenyl ethers** (Tetrabromodiphenyl ether and penta-bromodiphenyl ether)

Polybromodiphenyl ethers (PBDEs) are a group of brominated industrial chemicals which have been widely used since 1970s as flame retardants in form of additives in consumer products such as plastics in electronics, upholstery in transport and furniture or textiles (Shaw et al., 2010). The acronym PBDE is used for the generic term polybromodiphenyl ether, covering all congeners of the family of brominated diphenyl ethers (UNEP, 1999). PBDEs were produced at three different degrees of bromination, in particular PentaBDE, OctaBDE and DecaBDE (Alaee et al. 2003). The general chemical structure of PBDEs is shown in Figure 2-8.

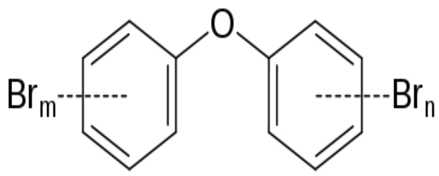

Figure 2-8 General chemical structure of PBDEs

Commercial pentabromodiphenyl ether (C-PentaBDE) refers to mixtures of congeners in which the main components are 2,2', 4,4'- tetrabromodiphenyl ether (BDE-47 CAS No. 40088-47-9) and 2,2',4,4',5-pentabromodiphenyl ether (BDE-99 CAS No. 32534-81-9). The POPs regulation focuses on Tetra- and Penta-BDE in the sense of the definition of the

Stockholm Convention and, therefore, means 2,2',4,4'-tetrabromodiphenyl ether (BDE-47, CAS No: 40088-47-9) and 2,2',4,4',5-pentabromodiphenyl ether (BDE-99, CAS No: 32534-81-9) and other tetra- and pentabromodiphenyl ethers present in commercial pentabromodiphenyl ether. Commercially available PentaBDE (c-Penta-BDE) is not a pure substance but is instead a mixture of various congeners. The total global market demand for commercial PBDE is shown in Table 2-2 and the compositions of c-PentaBDE and c-OctaBDE are shown in Tables 2-3 and 2-4 respectively.

Table 2-2: Total market demand by region in 2001 in metric tons (and by percent) (Bergerman 1989)

	Americas	Europe	Asia	Rest of world	Total
PentaBDE	7,100	150	150	100	7,500
OctaBDE	1,500	610	1,500	180	3,790
DecaBDE	24,500	7,600	23,000	1,050	56,100

Table 2-3: Composition of c-PentaBDE (La Guardia, 2007)

Categories of PBDE	**Tribromodi-phenyl Ethers**		**Tetrabromodi-phenyl Ethers**	**Pentabromodi-phenyl Ethers**		**Hexabromodi-phenyl Ethers**	
CAS No	49690-94-0		40088-47-9	32534-81-9		36483-60-0	
Congener	BDE-17	BDE-28	BDE-47	BDE-153	BDE-153	BDE-153	BDE-154
Content	0-1%		24-38%	50-62%		4-12%	
	Traces	Traces	Traces	Minor	Minor	Minor	Traces
Used for Calculations			31%	56%		9%	

Table 2-4: Composition of c-octabde (La-Guardia, 2007)

Categories of PBDE	Hexabromodi-phenyl Ethers		Heptabromodi-phenyl Ethers			Octabromodi-phenyl Ethers			Nonabromodi-phenyl Ethers		Decabromodi- phenyl Ethers
CAS No	36483-60-0		68928-80-3			32536-52-0			63936-56-1		1163-19-5
Congener BDE-	154	153	183	180	171	197	203	196	206	207	209
Content (%)	0.04-1.1	0.15-8.7	13-42	n.d.-1.7	0.17-1.8	11-22	4.4-8.1	3.1-10.5	1.4-7.7	11-12	1.3-50
	Traces	minor	Major	Traces	Traces	Major	minor	minor	minor	minor	Traces/Major
Used for Calculations	5%		42%*			37%*			13%		2%*

*: c-OctaBDE=Maximum (BDE-183/0,42;(BDE-197+BDE-196+BDE-203)/0,37;BDE-209/50)

c-PentaBDE was produced in Israel, Japan, U.S. and the EU and it is possible that China produced for their market as well (La Guardia, 2007). Production in the EU ceased in 1997. It is assumed that since the late 1990’s c-PentaBDE was mainly produced in the U.S (Darnerud et al., 2001).

The compilation of the PBDE production data for the POP Reviewing Committee (UNEP/POPs/POPRC/6.2) estimated that the total production of all PBDE from 1970-2005 was between 1,300,000 and 1,500,000 tonnes with use of commercial PentaBDE and OctaBDE each around 100,000 tonnes (Table 2-5). The DecaBDE - not listed as POPs in the Convention – has a historic production volume of more than 1 million tonnes (UNEP, 2009). While the production of commercial c-PentaBDE and c-OctaBDE has stopped, the production of DecaBDE still continues.

Table 2-5: Estimated total production of PBDE commercial mixtures 1970 to 2005 (UNEP 2009)

Commercial Mixture	Tonnes
DecaBDE	1,100,000 to 1,250,000
c-OctaBDE	102,700 to 118,500
c-PentaBDE	91,000 to 105,000

Despite the stoppage in the production and use of c-PentaBDE and c-OctaBDE, large amounts of these POPs are still in use particular in plastics, electronics, upholstery, transport and furniture. The deposition of PBDE containing materials have created reservoirs in landfills and sediments and these will serve as future source of PBDEs into the environment (e.g., landfills, wastewater treatment plants, electronic waste recycling facilities, or stockpiles of hazardous wastes). Furthermore, large volumes of these materials are in the global recycling flow (e.g., plastic from waste electronics or polyurethane foam recycled to carpet padding) and will continue to be used in consumer products for a considerable time (Schlummer et al., 2006).

Available information indicates that PBDEs have never been produced in South Africa, but are imported as formulations and products containing PBDEs as flame retadants.

2.3 **Analysis of the production, use and alternatives to POP-PBDEs/PFOS** listed under the Stockholm Convention

This section provides a background to the current production, use, and trade; alternatives of the listed chemicals. This section also highlights trends in consumption and analyses the major applications of POP chemicals.

2.3.1 Former uses of POP-PBDEs

The main manufacturing sectors that have used POP-PBDEs are as follows:

- Organobromine industry;
- Electrical and electronics industry;
- Transport industry;
- Furniture industry;
- Textiles and carpet industry;
- Construction industry and
- Recycling industry;

2.3.2 Production of c-PentaBDE

c-PentaBDE was produced in Israel, Japan, the United States and the European Union (EU), and possibly China (UNEP, 2006a, 2010b). Production in the EU ceased in 1997. It is assumed that since the late 1990s POP-PBDEs were mainly produced in the United States and production ended in 2004. c-OctaBDE was produced in the Netherlands, France, the

United States, Japan, United Kingdom and Israel. Production stopped in the EU, United States and the Pacific Rim in 2004, and there is no information indicating that it is being produced in developing countries (BSEF, 2007).

The compilation of PBDE production data prepared for the POPs Reviewing Committee (POPRC) of the Stockholm Convention estimated the total production of all PBDEs from 1970 to 2005 as between 1.3 million and 1.5 million tonnes (UNEP, 2010a). The total amounts of c-PentaBDE and c-OctaBDE used in the world were estimated at around 100,000 tonnes each. The production of c-DecaBDE which is not listed, was estimated at over 1.1 million tonnes until 2005 (Table 2-6). While the production of POPs c-PentaBDE and c-OctaBDE ended in 2004, the production of DecaBDE continues.

Table 2-6: Estimated total production of PBDE commercial mixtures, 1970-2005

Commercial mixture	**Tonnes**
c-PentaBDE	91,000 to 105,000
c-OctaBDE	102,700 to 118,500
c-DecaBDE	1,100,000 to 1,250,000

Source: UNEP, 2010a; derived from Schenker et al., 2008 and Li et al., 2010
There is no record of production of POP-PBDE in South Africa

The aforementioned uses can be applicable to South Africa. However, the presence of these POP-chemicals is expected to be more predominant in imported goods.

2.3.3 Former uses of c-PentaBDE

It is considered that between 90% and 95% of the use of c-PentaBDE was for the treatment of polyurethane (PUR) foam. These foams were mainly used in automotive and upholstery applications. Minor uses included textiles, printed circuit boards, insulation foam, cable sheets, conveyer belts, lacquers and possibly drilling oils (UNEP, 2007). The total amount of c-PentaBDE used for these minor uses is estimated to account for 5% or less of the total usage (SFT, 2009; UNEP, 2010b). Alcock et al. (2003) estimated that 85,000 tonnes of c-PentaBDE were used overall in the United States and the remaining 15,000 tonnes in Europe. There may have been production and use in Asia but reliable data are not available. An approximate distribution of global c-PentaBDE use of 36% in transport, 60% in furniture and a 4% residual in other articles is considered to be reasonable and is generally consistent with the analytical data for different waste streams (UNEP, 2010b). Table 2-7 summarizes the former uses of c-PentaBDE in various materials and applications.

Table 2-7: Former uses of c-PentaPBDE in polymers/resins and their applications and articles

Materials/polymers/resins	Applications	Articles
Polyurethane (PUR)	Cushioning materials, packaging, padding, construction	Furniture, transportation, sound insulation, packaging, padding panels, rigid PUR foam construction
Textiles	Coatings	Back coatings and impregnation for carpets, automotive seating, furniture in homes and official buildings, aircraft, underground
Epoxy resins	Circuit boards, protective coatings	Computers, ship interiors, electronic parts
Rubber	Transportation	Conveyor belts, foamed pipes for insulation
Polyvinylchloride (PVC)	Cable sheets	Wires, cables, floor mats, industrial sheets
Unsaturated (Thermoset) polyesters (UPE)	Circuit boards, coatings	Electrical equipment, coatings for chemical processing plants mouldings, military and marine applications: construction panels
Paints/lacquers	Coatings	Marine and industry lacquers for protection of containers
Hydraulic oils	Drilling oils, hydraulic fluids	Off shore, coal mining

Source: UNEP, 2009

The average content of c-PentaBDE in PUR foam is reported to be around 3-5% (wt %) for upholstery, cushions, mattresses, and carpet padding (ENVIRON, 2003; UNEP, 2010a; SEE Table 2.8), used in particular in countries with flammability standards for these applications (e.g. United States, United Kingdom). PUR foam in the transport sector might have been used in lower concentrations for applications like seats or arms/head rests at 0.5-1 wt % (Ludeka, 2011). Considering the approximately 100,000 tonnes of c-PentaBDE and a use of 4% in PUR foam, the historic production of c-PentaBDE treated foam can be conservatively estimated to be approximately 2.5 million tonnes. This number might have been significantly higher considering that a major application (PUR foam in transport in the United States) used c-PentaBDE at a lower level. Furthermore, recycling of contaminated PUR foam mixed together with non-impacted PUR foam led to increased total quantities of POP-PBDEs-contaminated PUR foam materials.

Table 2-8: Usage of pentaPBDE in PUR foam

PUR foam density/use area	PentaBDE in Polymer (wt %)
[a]19 kg/m^3	5.45
[a]24 kg/m^3	4.30
[a]29 kg/m^3	2.77
[b]PUR foam in (US) transport (seating, head/arm rest)	0.5-1
bolded carpet padding	2.5
[b]lamination to headliner fabric	up to 15

Source: [a]Cambell, 2010; [b]Ludeka, 2011

2.3.4 Former uses of c-OctaBDE

The main former use of c-OctaBDE was in acrylonitrile-butadiene-styrene (ABS) polymers, accounting for about 95% of c-OctaBDE supplied in the EU. The treated ABS was mainly used for housings/casings of electrical and electronic equipment (EEE), particularly for cathode ray tube (CRT) housings and office equipment such as copying machines and business printers. Other minor uses were high impact polystyrene (HIPS), polybutylene terephthalate (PBT), and polyamide polymers. Although the majority of these polymers were used in electronics, there was also some use in the transport sector. Other minor uses found in literature include nylon, low density polyethylene, polycarbonate, phenolformaldehyde resins, unsaturated polyesters, adhesives and coatings (UNEP, 2010a, 2010b). Table 2-9 summarizes the former uses of c-OctaBDE in various materials and applications. Typical concentrations in the major applications were between 12 wt% and 18 wt%, with approximately 100,000 tonnes of c-OctaBDE at an application rate of 15 wt%. The primary treated polymers can be estimated at approximately 800,000 tonnes. Considering the recycling of c-OctaBDE in new plastic products (secondary contamination), the total quantity of impacted plastics is likely to be considerably higher than this.

Table 2-9: Former uses of c-OctaBDE in polymers/materials, the applications and products (ESWI, 2011)

Materials/polymers/resins	Applications	Articles
Acrylnitrile-Butadiene-Styrene (ABS)	Polymer casings/parts in electric and electronic appliances	Furniture, transportation, sound insulation, packaging, padding panels, rigid PUR foam construction
High Impact Polystyrene (HIPS)	Polymer casings/parts in electric and electronic appliances	Back coatings and impregnation for carpets, automotive seating, furniture in homes and official buildings, aircraft, underground
	Cold-resistant layer	Refrigerator
Polybutylen-Terephtalate (PBT)	Polymer casings	Electronic appliances
	Transport sector	Connectors in vehicles
	Household	Iron
Polyamide-Polymers	Textiles	Furniture
	Construction	Pipes and plastic foil

2.3.5 POP-PBDEs in material/recycling flows and at end-of-life

Even though POP-PBDEs are considered to be no longer produced, the main challenge for their elimination is the identification of existing stockpiles and articles containing POP-PBDEs and their disposal at end-of-life. Large volumes of these materials are in the global recycling flow and will continue to be used in consumer articles (UNEP, 2010a, 2010b; Shaw et al., 2010). The existing reuse and recycling of materials and wastes containing POP-PBDEs was the trigger for the COP4 specific exemption that allows recycle and reuse under certain conditions. This is addressed in the Guidance on Best Available Techniques and Best Available Practices for the Recycling and Disposal of Articles Containing Polybrominated Diphenyl Ethers (PBDEs) under the Stockholm Convention on Persistent Organic Pollutants (PBDE BAT/BEP Guidance; Secretariat of the Stockholm Convention, 2012).

2.3.6 c-PentaBDE in reuse, recycling and waste flows

The main uses of c-PentaBDE were in PUR foam used in the transport sector (e.g. cars, buses, trains etc.) and furniture (e.g. couches, seats, cushions etc.), with limited use in mattresses and some other uses. Therefore, the reuse and recycling of these major material flows need to be considered in the inventories where information is available.

2.3.7 Transport

The lifespan for cars in industrial countries is 10 to 12 years, while buses and trains might have a longer life expectancy. A considerable share of cars and other transport has been and is still being exported from industrial countries to developing countries and countries with economies in transition where the vehicles are often used for a long time before they finally break down (spare parts are also used further) (UNEP, 2010a, 2010b). Therefore, today a large share of the transport fleet from 1970 to 2004 (cars, buses and possibly trains) containing c-PentaBDE is still in operation today, likely in developing countries, and will need to be identified in respect to reuse and recycling when these vehicles reach end-of-life. It is therefore reasonable to assume that the transport sector (cars, trucks, buses, trains, ship, and planes) is the largest stockpile for c-PentaBDE in developing countries.

2.3.8 Furniture and mattresses

The use of c-PentaBDE (and other flame retardants) in furniture or mattresses depends on the flammability standards of a country (Shaw et al., 2010). Due to flammability standards for furniture in the United States and United Kingdom, in particular, furniture in North America and the United Kingdom is often flame retarded. Therefore, old furniture and mattresses (in particular from institutions like prisons, military facilities, hospitals or hotels) in these regions/countries may contain c-PentaBDE (and other flame retardants).

The lifespan of furniture in industrial countries is estimated at about 10 years. Therefore it is estimated that a considerable share of furniture containing c-PentaBDE in these regions has been deposited or incinerated (ESWI, 2011) with a minor share recycled e.g. in carpet rebond (see below). The extent of furniture exported from North America and the United Kingdom for reuse and recycling to other regions has not been assessed and needs to be considered as a possible source for c-PentaBDE input for other countries. c-PentaBDE was also used in rigid PUR foam in construction, but this is considered a minor use. Further recycling activities of rigid PUR foam are not known.

2.3.9 Textiles and rubber

c-PentaBDE has been used in limited quantities for the treatment of textiles for uses including back-coating, for curtains and for functional textiles (UNEP, 2009). Although the extent of recycling of POP-PBDEs-containing textiles is unclear, it can reasonably be assumed to be small for composite materials such as those used in transport. There may be some limited recycling of other c-PentaBDE-containing textiles but it is likely that only relatively small quantities of POP-PBDEs-containing textiles are in use as the application of c-PentaBDE stopped about a decade ago. The POPRC decision to recommend hexabromocyclododecane (HBCD), for which the textile sector is a major application, to the Conference of Parties for listing as a POP might imply that the management of textiles treated with BFRs with POPs-like properties could become more relevant in the near future.

2.3.10 Printed circuit/wiring boards

The use of c-PentaBDE in printed circuit/wiring boards (PWBs) has been phased out. PWBs are a component of WEEE that ends up in certain developing countries, where the metals are recovered using primitive methods in the informal sector, or by simple smelters. This can be the source of certain levels of POP-PBDEs and PBDD/PBDF (Yu et al., 2008). The inventory of PWBs in the country needs to be carried out in relation to the POP-PBDEs inventory.

2.3.11 Recycling of PUR foam to new articles

PUR foams in furniture, transport, end-of-life vehicles and mattresses are partly recycled into new articles by processes such as carpet rebond and regrinding. The resulting new articles need to be captured by the inventory.

2.3.12 Carpet rebond

Large-scale recycling of PUR foam into carpet padding/rebond is currently practised in the United States and Canada (Ludeka, 2011; see Chapter 6 of the *PBDE BAT/BEP Guidance*). The extent of this recycling activity in other regions is unknown but appears to be limited (DiGangi et al., 2011). Relevant exposure of PUR recyclers and carpet installers to POP-PBDEs has been demonstrated in a first study in the United States (Stapleton et al., 2008), and there are obvious risks of further exposure of consumers.

2.3.13 Other uses

While the majority of PUR foam scraps is processed into carpet rebond (in the US market), scrap can also be shredded and used as packaging and stuffing for pillows, pet bedding, insulation and staffed toys. Foam scraps might also be used for some furniture cushioning, sound insulation, gymnastic mats, or school bus seats (UNEP, 2010b; USEPA, 1996; Zia et al., 2007).

2.3.14 Re-grinding

Eaves (2004) noted that this innovative process allowed manufacturers to non-cryogenically grind foam scraps into ultrafine powders that displaced approximately 20% of the virgin material in the manufacture of new foams.

2.3.15 c-OctaBDEs in reuse, recycling and waste flows

Europe and Japan stopped the use of c-OctaBDE in the 1990s. The production of c-OctaBDE in the United States stopped in 2004. The largest c-OctaBDE content is found in polymers (in particular ABS and HIPS) that are used in EEE and WEEE. The use of c-OctaBDE in polymers in the transport sector was limited.

2.3.16 EEE in use, second-hand EEE and WEEE electronic waste

Electronics produced before 2005 may be flame retarded with c-OctaBDE. The main appliances are televisions and computer CRT monitors. Large quantities of old EEE and WEEE were - and in some cases still are - exported from industrial countries/regions (e.g. United States, Europe and Japan) to developing countries for reuse or recycling. Primitive recycling technologies for WEEE have resulted in large contaminated areas in developing countries and exposure of recyclers and the general population (Wong et al., 2007; UNEP, 2010a, 2010b).

2.3.17 Plastics from WEEE recycling and production of articles from recycled plastic

The mechanical recycling of plastic for further use is strongly favoured from a waste hierarchy and life cycle assessment perspective. When plastics are contaminated with POPs and other hazardous materials, however, particular care has to be given to how the waste hierarchy is followed. The recycling of WEEE results in a fraction of flame-retarded plastic, possibly containing POP-PBDEs. Some plastic from WEEE is sent to developing countries such as China and India where it is recycled into new articles. Recent studies have shown that plastics containing POP-PBDEs and other BFRs have been recycled in the production of articles for which no flame retardancy is required including children's toys, household goods and video tapes (Hirai & Sakai, 2007; Chen et al., 2009; Chen et al., 2010). This shows that the flow of plastics containing POP-PBDEs and other flame retardants for recycling are not well controlled and that plastics containing POP-PBDEs are being mixed with non-flame retarded polymers for the production of items with sensitive end uses. Therefore, in some cases, the use of recycled plastic may be significantly more hazardous than the original use (recycling from a printer housing into a toy that may be chewed by a child, for example).

2.3.18 Potential contaminated sites

All sites where POP-PBDEs have been used for any of the activities could be considered as contaminated sites with POP-PBDEs. Landfills are the ultimate destination of many POP-PBDEs-containing materials due to their widespread application in a multitude of consumer and industrial goods. POP-PBDEs can be leached from refuse by landfill leachate.

POP-PBDEs are precursors of brominated dibenzofurans (PBDF) and dibenzo-p-dioxins (PBDD). They are largely formed during primitive recycling of e-waste and incineration of POP-PBDEs-containing materials (UNEP, 2010b). The locations of these activities should also be identified. In addition, biosolids from wastewater treatment plants are known to contain POP-PBDEs, which were disposed in landfills and applied in agricultural lands.

Despite the stop in the production and use of c-PentaBDE and c-OctaBDE, large amounts of these POPs are still in use particular in plastics, electronics, upholstery, transport and furniture. The deposition of PBDE containing materials have created reservoirs in landfills and sediments and these will serve as future source of PBDEs into the environment (e.g., landfills, wastewater treatment plants, electronic waste recycling facilities, or stockpiles of hazardous wastes). Furthermore, large volumes of these materials are in the global recycling flow (e.g., plastic from waste electronics or polyurethane foam recycled to carpet padding) and will continue to be used in consumer products for a considerable time˙ Furthermore, any remaining stockpiles must be eliminated or be subject to environmentally sound management.

2.4 Alternatives Halogenated Flame Retardants

2.4.1 Decarbromodiphenylethane (DBDPE)

This compound is a relatively new flame retardant (introduced in 1990s) and its applications are same as deca-BDE. Two reports have appeared identifying this compound in sewage sludge from Sweden and Canada with concentrations of 10-100 ng/g dry weight. DBDPE was also present in tree bark at low levels. This compound may be on its way to becoming environmentally widespread.

2.4.2 Pentabromotoluene (PBT)

This is a relatively unknown flame retardant manufactured under the trade names of Bromcal 81-5 T and Flammex 5 BT. It has been found in air in the U.S. It has also been found in sediment from Germany. Interestingly, a related compound, pentabromoethylbenzene (PBEB), has also been found in air, with an especially high concentration on one day in Chicago. This later compound is a flame retardant that is manufactured by the Albemarle Corp. in France. It is not yet clear if either of these compounds will become environmentally ubiquitous.

2.4.3 1,2-*Bis*(2,4,6-tribromophenoxy)ethane (TBE)

This compound has been suggested for use as a replacement for the octa-BDE product that is no longer being manufactured. TBE has been found in the environment in the atmosphere and in air from ambient indoor and occupational settings. The environmental data for TBE are from Sweden and North America. Indoor air in Sweden had concentrations of 4-40 pg/m^3, while an electronics disassembly plant had air concentrations of 10,000 pg/m^3. TBE has also been found in sediment from the Great Lakes and in tree bark from North America. Clearly this compound warrants further attention.

2.4.4 Chlorinated paraffins (CPs)

One prevalent class of chlorinated flame retardant is the chlorinated paraffins, which are complex mixtures of chlorine substitution patterns and paraffin chain lengths. CPs has been found in air, fishes, and sediment from all over the world (see Santos et al., 2006, for an up-to-date review). In many cases, the concentrations of the CPs are similar to those of PBDEs in the same type of sample matrix.

2.4.5 Dechlorane

This compound (a dimer of hexachlorocyclopentadiene) was also known as Mirex, an insecticide that was used to kill fire ants in the southern U.S. It was also sold under the name Dechlorane as a flame retardant, and in fact, the amount sold for this later application was much greater than that sold as an insecticide. Dechlorane was manufactured by OxyChem (formerly known as Hooker Chemical) in Niagara Falls, New York, and perhaps as a result, this compound is relatively abundant in the sediment of Lake Ontario, which is downstream of the manufacturing site. Dechlorane is now off the market, but it is still found occasionally at low levels in the environment; for example, it is present in farmed salmon from all over the world.

2.4.6 Dechlorane Plus (DP)

This is a highly chlorinated flame retardant that was detected and identified in ambient air, fish, and sediment samples from the Great Lakes regio. This compound exists as two gas chromatographically separable stereoisomers (*syn* and *anti*), and they were detected in most air samples, even at remote sites. The atmospheric DP concentrations were higher at the eastern Great Lakes sites (Sturgeon Point, New York, and Cleveland, Ohio) than at the western Great Lakes sites (Eagle Harbor, Michigan, Chicago, Illinois, and Sleeping Bear Dunes, Michigan). At the Sturgeon Point site, DP concentrations once reached 490 pg/m^3. DP atmospheric concentrations were comparable to those of BDE-209 at the eastern Great Lakes sites. DP was also found in sediment cores from Lakes Michigan and Erie. The peak DP concentrations were comparable to BDE-209 concentrations in a sediment core from Lake Erie, but were about 20 times lower than BDE-209 concentrations in a core from Lake Michigan.

2.5 Halogen free flame retardants

2.5.1 Triphenyl Phosphate Plasticizer

This is a solid that is most commonly used flame retardant for Cellulose Acetate. It is compatible with many vinyl resins, cellulosics and synthetic rubber. In vinyl compounds, however, it should be used in conjunction with a liquid plasticizer to prevent crystallizing and blooming. In Cellulose Acetate films, Triphenyl Phosphate imparts flame resistance, good clarity, excellent water resistance, good flexibility and toughness.

2.6 Perfluorooctane sulphonate (PFOS)

2.6.1 Production and use of PFOS and its related substances

PFOS-related substances have been manufactured for more than 50 years. Their unique physical properties, being both fat and water repelling, have made them popular in several products. They are typically used for surface treatment, and are common in non-stick products, stain-resistant fabrics and all-weather clothing. Due to their surface-active properties, they have historically been used in a wide variety of applications, typically including fire fighting foams and surface resistance/repellence to oil, water, grease or soil. The global use pattern is described in Table 2-10 (UNEP, 2006), in which estimates of the global usage amount are based on 3M Company estimates from 2000 (3M Company, 2000). Since then, PFOS has been phased out for several uses in some regions. 3M, for example, ended its production in 2003. At around the same time, production started in Asia and has increased in this region since then (UNEP, 2006).

Table 2-10: The global use of PFOS and its related substances (UNEP, 2006)

Main category	Setting	Applications	Global usage amount, 2000[a] (metric tons)
Surface treatments	Industrial	Textile mills, leather tanneries, finishers, fibre producers, carpet manufacturers	2,160
	General public or professional applicators aftermarket treatment	Apparel and leather, upholstery, carpet, automobile interiors	
Paper protection	Paper mills	Food contact applications (plates, food containers, bags, and wraps), non-food contact applications (folding cartons, containers, carbonless forms, masking papers)	1,490
Performance chemicals	Industrial, commercial, and consumer applications	Fire fighting foams	151
		Mining and oil well surfactants, acid mist suppressants for metal plating, electronic etching baths, photolithography, electronic chemicals, hydraulic fluid additives, alkaline cleaners, floor polishes, photographic film, denture cleaners, shampoos, chemical intermediates, coating additives, carpet spot cleaners, insecticide in bait stations	680

[a]Global usage amounts from 3M Company estimate (3M Company, 2000)

PFOS and its related substances are widely used in many applications and type of industries, and are widely spread in the product chain. Some uses are in open applications with potential exposure of humans and environment, while others are in closed controlled systems. PFOS-containing products and articles and landfills have been identified as important sources of exposure of humans and the environment. Past depositions in landfills have to be investigated, as well as the management of contaminated sludge that has been applied as a biosolid to agricultural areas or other soils in some countries. In many countries the safe management of waste, stockpiles and contaminated sites is of special importance because of dispersive use in the past. Some articles are recycled (e.g. aviation hydraulic fluid, synthetic carpets and paper) and the content of PFOS in new articles made from the recycled articles can be of concern.

The manufacture of products and articles containing PFOS can comprise several producers, suppliers and downstream users and the supply chain can involve import and export across borders (Figure 2-9). The preparations used in the manufacture of articles are often imported and distributed by suppliers to the professional users in the national manufacturing industry. For most countries only the professional users of PFOS, the national supply chain and the downstream users in the product chain for articles containing PFOS have to be identified and described.

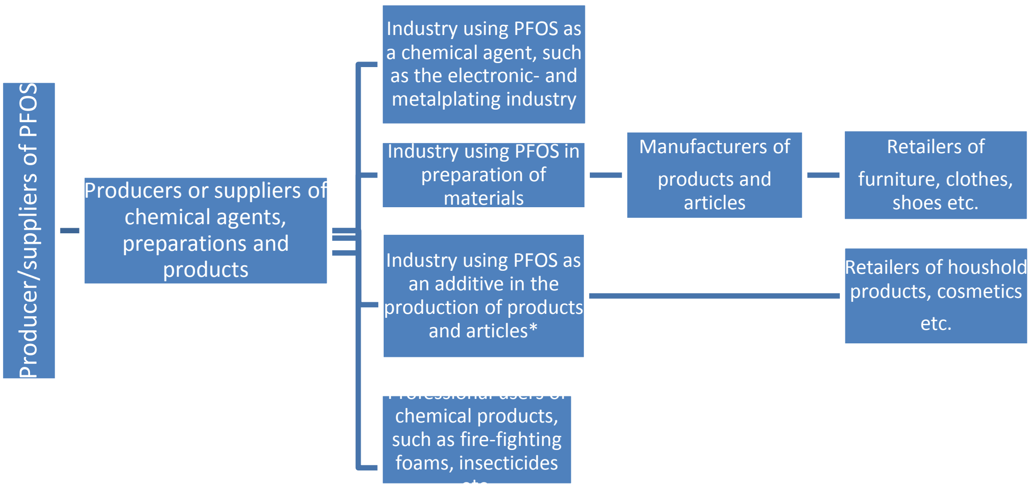

Figure 2-9: Description of the PFOS supply chain (UNEP, 2010a)

2.6.2 Manufacture of articles and products using PFOS as a chemical

PFOS and its derivatives are used in numerous manufacturing processes because of their non-reactive properties, low surface tension, chemical stability, resistance to acids and high temperature. PFOS-related substances have various specific uses as a chemical agent in the electronics, semiconductor and photographic industries. They are used in small quantities in closed systems and are not intended to be a content of the final end products. The production chain can be complicated and downstream users may not know that PFOS has been used in the preceding manufacturing processes.

PFOS and PFOS-related substances are also used as surfactants for oil well stimulation in the oil and gas industry, drilling fluids in the mining industry, and as surfactants or wetting agents in the metal plating industry. The metal plating process can be in a closed system; the baths are then reused and delivered for treatment as hazardous waste, when they are no longer useful. However, in many countries the process is not closed and can represent important point sources of releases of PFOS-related substances to the environment. The use of PFOS in the oil and mining industries has the potential to release into water and the ground at the production sites, resulting in contaminated sites.

2.6.3 Electronics industry

Electrical and electronic equipment often requires hundreds of parts and thousands of processes. PFOS has many different uses in the electronics industry and is involved in many of the production processes needed for electric and electronic parts (Figure 2-10). PFOS-based chemicals are used in the manufacturing of digital cameras, cell phones, printers, scanners, satellite communication systems, radar systems and the like. The PFOS-related compounds are process chemicals, and the final products are mostly PFOS-free. Some of the processes are related to semiconductors, and are also used in the semiconductor industry. Many electronic articles have plated metal parts that are supplied by the metal plating industry.

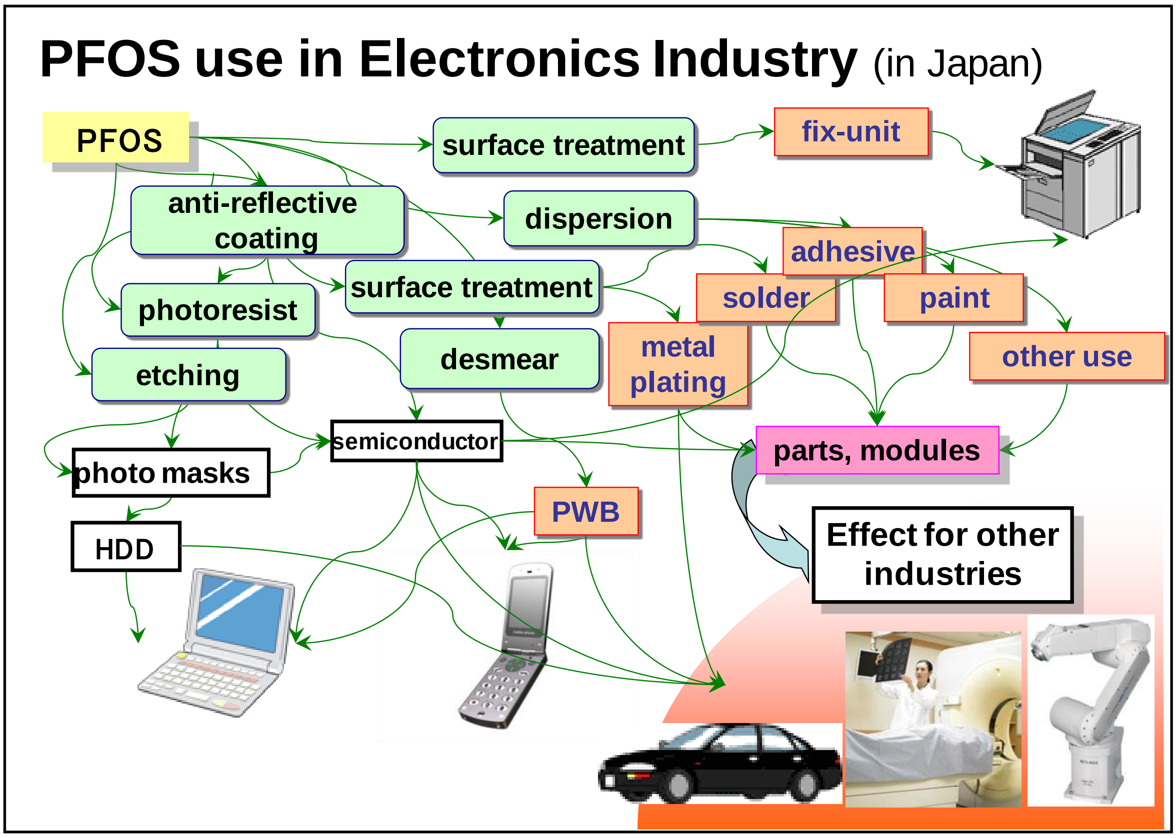

Figure 2-10: PFOS use in electronics industry supply chain (UNEP, 2010a)

PFOS reduces the surface tension and reflection of etching solutions, properties that are important for precise photolithography in the semiconductor industry (photo resists and photo masks). Small amounts of PFOS-based compounds are required during the following photolithography applications, which are crucial for achieving the accuracy and precision required to manufacture miniaturized high-performance semiconductor chips:

- Ultra-fine patterning/photo resists as photo-acid generators and/or surfactants
- Anti-reflective coatings as uniquely performing surfactants

No alternatives are available that would allow for the comprehensive substitution of PFOS in these critical applications. Non-critical uses of PFOS are as edge bead removers, de-gluing agents and developing agents. PFOS is used as a component of a photoresistant substance, including a photo acid generator or surfactant; or of an anti-reflective coating, used in a photomicrolithography process to produce semiconductors or similar components of electronic or other miniaturized devices.

2.6.4 Semiconductor industry

PFOS and PFOS-based substances are chemicals required by the semiconductor industry for formulation of resists and anti-reflective coatings in high-end lithography. PFOS is a process chemical; it does not remain in the final product – the semiconductor device. Semiconductor manufacturing comprises up to 500 steps involving four fundamental physical processes:

- Implant;
- Deposition;
- Etch; and
- Photolithography.

Photolithography is the most important step out of the four processes. It is essential for the successful performance of the other three steps and of the overall production process. It shapes and isolates the junctions and transistors; it defines the metallic interconnects; it delineates the electrical paths that form the transistors; and it joins them together. Photolithography reportedly represents 150 of the total 500 steps. Photolithography is also integral to the miniaturization of semiconductors.

2.6.5 Photographic industry

PFOS-based chemicals are used for the following purposes in mixtures, in coatings applied to photographic films, papers, and printing plates:

- Surfactants;

- Electrostatic charge control agents;
- Friction control agents;
- Dirt repellent agents; and
- Adhesion control agents.

The uses of PFOS in this industry include coatings for surface tension, static discharge, and adhesion control for analogue and digital imaging films, papers, and printing plates; and as a surfactant in mixtures used to process imaging films.

2.6.6 Metal plating industry

PFOS-related substances are mainly used as surfactants/wetting agents/mist suppressants in hard and decorative chrome plating, which can reduce the emission of chromium and improve the working environment in this sector. Besides chrome plating, fluorosurfactants (including PFOS) are also used in other metal plating applications, such as agents to prevent haziness of plated copper by regulating foam and improving its stability, non-foaming surfactants in nickel-plating baths to reduce surface tension, and agents added to tin-plating baths to ensure that plating has uniform thickness.

2.6.7 Chemically driven oil and gas production

PFOS and its related substances may be used as surfactants in the oil and gas industries to enhance oil or gas recovery in wells, as evaporation inhibitors for gasoline, and as jet fuel and hydrocarbon solvents. As late as 2009, PFOS and its related substances were reportedly used as a surfactant in old oil fields in some regions to recover oil trapped in small pores between rock particles. At the same time, oil and gas production and mining were reportedly carried out without the use of PFOS and its related substances in other countries, including developing countries, thus indicating the existence of alternative processes that did not require PFOS.

2.6.8 Mining industry

PFOS derivatives may occasionally be used as surfactants in the mining industry to enhance the amount of recovery in copper and gold mines. Tetraethylammonium perfluorooctane sulfonate and potassium perfluorooctane sulfonate have been used as suppressing agents in mining in OECD countries. There can be large-scale mining activities in developing countries, as well as mining operations of the artisanal-small scale type still using PFOS. Other activities also include quarrying operations by construction companies. Since the major challenge in many developing countries is addressing the problem of mercury and lead poisoning from artisanal small-scale gold mining, the use of PFOS has usually not been addressed.

2.6.9 Manufacture of plastic and rubber products

Because of good surfactant properties with extremely stable and nonreactive characteristics, perfluorocarbons (PFCs), including PFOS, are used in release agents for plastic and rubber products manufacture. A release agent is a chemical, often wax, silicone or fluorocarbon fluid, used in moulding and casting, that aids in the separation of a mould from the material being moulded. It reduces imperfections in the moulded surface; it is also known as a parting agent, mould lubricant, mould release lubricant and de-moulding agent. PFCs, however, were only used as a low concentration additive for a release agent, in which wax, hydrocarbons and organosilicons would be the basic ingredients.

2.6.10 Impregnation and coating industry

Fluorosurfactants and polymers have been used to treat textiles and leather to provide oil and water repellence and soil and stain release properties, and to provide oil, grease and water repellence for paper. Fluorinated polymers are used to render textiles stain- and waterproof when required, but they also have to keep their breathability (air and water-vapour permeability. Fluorinated finishes are the only technology known to deliver durable and effective oil and water repellence and release properties. Historically, fluorinated polymers based on perfluorooctane sulfonyl electrochemical fluorination chemistry have been used.

2.6.11 Compounders

Compounders are manufacturers of commercial chemical mixtures, like aviation hydraulic fluids and impregnation formulas. They use manufactured PFOS and related substances provided by the chemical industry upstream in the supply chain in their production. Manufacturers of PFOS and its related substances can also be compounders. For example 3M produces PFOS and its related substances and is also a compounder of fire fighting foams.

2.6.12 Manufacture of articles

Manufacturers of articles containing PFOS and its related substances are at the end of the supply chain producing textiles, furniture, clothes, leather apparel, food packaging, etc. Major items that could contain PFOS and PFOS-related substances, in the form of consumer articles made available on the market, are synthetic carpets, paper, textiles, furniture, leather and surface coating. Information on the application of PFOS-related substances in 2000 indicated that over 75% of total PFOS consumption was in consumer articles (3M Company, 2000).

Applications with a potential risk of direct exposure, such as textiles, sports clothes, apparel, shoes, cosmetics, shampoos, food packaging, have been of special concern due to possible implications for human health. The use of PFOS in synthetic carpets, textiles and home furnishing is of concern because of findings of the presence of PFOS in house dust and indoor air, and of the direct exposure of humans, especially babies and smaller children (Moriwaki et al., 2003; Harada et al., 2005; Calafat et al., 2006a, 2006b).

PFOS has been measured in elevated levels in waste water effluents, sludge and sewage. The sources are wastewater from households and industry. Surveys of landfill sediments and effluents have also revealed elevated levels of PFOS, with waste from households as the primary source (Økland et al., 2008).

2.6.13 Recycling and Reuse of synthetic Carpets

Synthetic carpets may have been treated with PFOS and its related substances, while it has usually not been the case for natural fibre carpets. There are several major methods of recycling:

- **Chemical**: Chemical recycling involves breakdown of the nylon fibre to be reprocessed into new carpet fibre. Only certain kinds of virgin nylon compounds can be converted into new fibres;

- **Fiberizing:** Carpet fibres can be harvested and converted into padding and matting for use in laying new carpet; and

- **Mechanical:** Carpet fibres can be separated from their backing material and, if possible, recycled into new carpet or backing. The leftover materials can be processed into products such as parking barriers, geotextiles, lumber alternatives, roof shingles, fibreboard, sod reinforcement, carpet tack strip, automobile parts, high energy fuel, erosion control and soil absorbent, among other products.

Several companies also facilitate or manage leasing programs with the reuse of synthetic carpets. Recycling and reuse for synthetic carpets containing PFOS and its related substances are banned by the Stockholm Convention, and many of the products produced from recycled synthetic carpets represent a direct exposure of the environment and humans. The use of biosolids containing PFOS and its related substances are particularly problematic (USEPA, 2009a and 2009b). A strategy and actions to end recycling and reuse of synthetic carpets and a system for collecting and manage this waste stream in an environmentally sound manner will be important in the development of the NIP.

2.6.14 Consumer articles containing PFOS, its salts, PFOSF and its related substances

2.6.14.1 Textiles and upholstery

PFOS-related substances have been used to provide soil, oil and water resistance for textiles, apparel, home furnishing and upholstery. They are mainly applied to home textiles (e.g. upholstery, apparel) and to outdoor wear, especially work wear including uniforms. PFOS is found in sports socks and sportswear because of its sweat-repellent and dirt-repellent properties. These uses are still important in several countries, and are often found in imported goods.

Water-repellent and dirt-repellent textiles are impregnated with a chemical formula, a dispersion polymer containing PFOS. The acrylate, methacrylate, adipate and urethane polymers of N-ethyl perfluorooctane sulfonamidoethanol (EtFOSE) were one of the main PFOS derivatives previously used for textile surface applications (UNEP, 2010b). PFOS is found in house dust and indoor air, sewage sludge and releases from municipal treatment facilities. The washing of textiles is one of the sources of the releases of PFOS to water. The levels in house dust can be a result of releases from textiles, furniture and upholstery.

2.6.14.2 Synthetic carpets

Fluorinated compounds are widely used during manufacture of synthetic carpets to provide stain protection, especially for synthetic carpets based on synthetic fibres being impregnated. A small market share of synthetic carpets based on wool fibres is also impregnated. PFOS itself is not directly applied to the fibre, but is first chemically bound in a polymer, which is then applied to the carpet. The chemical formulae used for synthetic carpets impregnation are

usually manufactured by one producer using PFOS and then distributed downstream for carpet impregnation by a carpet manufacturer.
Examples of products used before 2003 for surface treatment of synthetic carpets include:

- Scotchgard (3M);
- Baygard (Bayer); and
- Zonyl (Dupont).

Dupont, Bayer and 3M have stated that they have not used PFOS in their preservatives since 2003, and that they use fluorotelomers instead. But PFOS and its related substances is still used in production of carpets in some countries. PFOS and its related substances may also be used, to make synthetic carpets stain proof after cleaning. In addition possible stockpiled PFOS-containing reimpregnation products may have been used after 2003 in countries where the use of PFOS and its related substances is phased out in the production of carpets.
Use in synthetic carpets is of concern because of the possible direct exposure of small children and babies. The washing of synthetic carpets can be a source of the releases of PFOS into water. The levels in house dust and indoor air can be a result of releases from synthetic carpets, among other sources in the home environment. Synthetic carpets remain in use for several years, and will eventually be deposited in landfills (Fricke et al., 2004). Recycling and use of synthetic carpets for other purposes have been reported, e.g., in the US and the United Kingdom (UK). Several reports have indicated that deposition of PFOS-related substances at dump sites and landfills have contaminated the surrounding environments, potentially posing risks to human health and the environment (Weber et al., 2010a, 2010b).

2.6.14.3 Leather and apparel

Leathers without finish have been impregnated with PFOS. These leathers have often been used for upholstery and belong to the higher price segment. The aim was to give surfaces the most natural look possible. For this purpose, PFOS was only sprayed onto the surface of such leathers to give them water- and stain-repellent properties. But PFOS has also been used for impregnation of leather shoes, domestic upholstery and in the automotive industry (European Commission, 2011).
Leather used in shoes, bags and apparel can be impregnated with water and dirt repellents. Using impregnation with PFOS preserves the product's ability to ventilate and transport the

moisture to the outside. Since the chemical formulation is rather expensive, the manufacturers usually use formulations without PFOS.

For the supply chain associated with treated leather, the chemical formulation used for leather impregnation are usually manufactured by a producer using PFOS and then distributed downstream for impregnation by a leather manufacturer. The impregnated materials are then further distributed to manufacturers of shoes, apparel and furniture, and to the automotive industry.

2.6.14.4 Paper and packaging

PFOS-related substances can be used in the packaging and paper industries in both food packaging and commercial applications to impart grease, oil and water resistance to paper, paperboard and packaging substrates, or a glossy finish. PFOS is applied to the paper, cardboards or cartons as a part of a polymer. Some of these articles are recycled and PFOS is transferred into new articles. The use of PFOS and its related substances in food packaging is particularly of concern because of the direct exposure and possible implications for human health, as well as the source for PFOS releases to the environment when it becomes waste, especially since the spread of this kind of waste is difficult to control. It is often mixed with other waste and thus cannot be sorted. It could have been landfilled or loaded on dump sites or given to domestic animals used for food production.

The following uses of PFOS formulations in food contact applications have been reported by different surveys (UNEP 2010 b; Begley et al. 2005):

- Plates;
- food containers;
- popcorn bags;
- pizza boxes and wraps;
- baking paper; and
- disposable plates

The following uses of PFOS in non-food contact applications have been reported by different surveys (UNEP 2010b; Begley et al. 2005):

- folding cartons;
- containers;
- carbonless forms and masking papers;
- table clothes ; and
- wall paper

Paper protection by PFOS derivatives has been achieved by using one of the following (UNEP 2010b):

- Mono-, di- or triphosphate esters of N-ethyl perfluorooctane sulfonamidoethanol;

- (EtFOSE); and
- N-Methyl perfluorooctane sulfonamidoethanol acrylate polymers.

The use of PFOS in paper and packaging applications is being reduced or phased out in many countries. PFOA and fluorotelomers are more frequently used today (UNEP 2010b). Common fluor-free applications, like denser paper, plastic films, and silicone emulsions, also fulfil the same purpose in consumer articles (UNEP 2010b). Before 2000 about 32% of the total use of PFOS in the European Union was for paper coating; the use of PFOS for this purpose is no longer allowed and PFOS has been replaced mainly by other fluorinated chemicals (UNEP 2010b).

Before 2000, a Canadian study of fast food composites revealed that more than 55% of the composites contained *N*-ethyl perfluorooctane sulfonamide (EtFOSA). The highest level measured (23.5 mg/kg) was in a pizza. The degradation product or impurity PFOS was also detected in three samples. Most samples taken after 2000 were free of these contaminants because fluorotelomers had since been substituted for PFOS (Tittlemier et al., 2003, 2006). The following are the main suppliers of fluorochemicals in the paper industry, with their brand names (UNEP 2010b):

- 3M Scotchban®;
- Bayer Baysize S®;
- Ciba (BASF) Lodyne;
- Clariant Cartafluor; and
- DuPont Zonyl.

2.6.14.5 Industrial and household surfactants

PFOS derivatives have been used as surfactants to lower surface tension and improve wetting and rinse-off in a variety of industrial and household cleaning products such as automobile waxes, alkaline cleaners, denture cleaners and shampoos, cosmetics and hand cream, dishwashing liquids, waterproof sprays and car wash products. PFOS derivatives have also been used in carpet spot cleaners. A PFOS derivative potassium N-ethyl-N-[(heptadecafluorooctyl) sulfonyl] glycinate has often been used in cleaning agents, floor polishes and auto polishes. The concentration of that PFOS precursor in the final product was generally between 0.005% and 0.01% but might have been 10 times as high (UNEP, 2010b).

2.6.14.6 Coatings, paint and varnishes

PFOS derivatives have been used in coatings, paint and varnishes to reduce surface tension for example, for substrate wetting, for levelling, as dispersing agents, and for improving gloss and antistatic properties. PFOS derivatives can be used as additives in dyes and ink, as pigment grinding aids, and as agents to combat pigment flotation problems. The concentrations used were below 0.01 wt%. Information from suppliers in the paint and varnish industries suggests that fluorosurfactants are in general much more expensive than other alternative surfactants. Therefore, they are used in paint and varnishes only in situations where a very low surface tension is needed that no other (non-fluorinated) alternatives can currently achieve (e.g. in articles where an extremely smooth surface is necessary).

2.6.14.7 Toner and printing ink

According to the information from the OECD (2006) survey, less than 1 tonne of N-ethyl-N-[3-(trimethoxysilyl) propyl] perfluorooctane sulfonamide has been used globally as an additive in toner and printing inks. This use is considered to have been discontinued in most regions.

2.6.14.8 Sealants and adhesive products

PFOS-related substances have historically been used in sealants and adhesive products (UNEP, 2010b).

2.6.14.9 Medical devices

Video endoscopes are used to examine and treat patients at hospitals. Around 70% of the video endoscopes used worldwide, or about 200,000 endoscopes, contain a CCD43 colour filter that contains a small amount (150 ng) of PFOS. Repairing such video endoscopes requires a CCD colour filter containing PFOS. Although it is technically possible to produce PFOS-free CCD filters for use in new equipment, the existing 200,000 endoscopes use PFOS-containing filters. Gradual phase-out of the existing endoscopes will permit use of PFOS-free equipment (UNEP, 2010b).

PFOS is also used as an effective dispersant when contrast agents are incorporated into an ethylene tetrafluoroethylene (ETFE) copolymer layer. PFOS plays an essential role in radio-opaque ETFE production, allowing the achievement of the levels of accuracy and precision required in medical devices (e.g. radio-opaque catheters, such as catheters for angiography and in-dwelling needle catheters). PFOS is only used as an agent in the manufacturing process and will normally not be a part of the final product as a result of this use (UNEP, 2010b).

2.6.14.10 Fire fighting foams

Fire fighting foams with fluorosurfactants are used for extinguishing liquid fuel fires, and are normally used to suppress fires in flammable liquids like oil, petrol, other non-water-soluble hydrocarbons, and flammable water soluble liquids like alcohols, acetone etc. They are especially used at installations and plants where larger quantities of flammable liquids are stored. Table 2-11 contains locations that may use and store PFOS containing fire fighting foams. The consumption of fire fighting foams depends on the frequency of fire drills and the rate of fire accidents. There are different types of fire fighting foams and agents containing PFOS or related substances:

- Fluoro-protein foams: used for hydrocarbon storage tank protection and marine applications;
- Aqueous film-forming foams (AFFF): used for aviation, marine and shallow spill fires; developed in the 1960s;
- Film-forming fluoroprotein foams (FFFP): used for aviation and shallow spill fires;
- Alcohol-resistant aqueous film-forming foams (AR-AFFF): multi-purpose foams; and
- Alcohol-resistant film-forming fluoroprotein foams (AR-FFFP): multipurpose foams; developed in the 1970s.

Fire fighting foams containing PFOS have been on focus due to the dispersive and extensive use and risk of high releases to the environment. Fire drills and leakage from stockpiles of fire fighting foams have led to contamination of groundwater and soil (Moody et al., 2003; Herzke et al., 2007). Because of the environmental problem, many countries have started to phase out PFOS-containing fire fighting foams at installations where alternatives satisfy the requirements for fire safety.

Table 2-11: Locations with possible use of fire fighting foams containing PFOS and its related substances (SFT, 2005)

Location	Quantities stored	Use of PFOS and its related chemicals
Fire fighting training sites and fire rescue brigades	Varies	The use of PFOS-containing fire fighting foams at fire fighting training sites and by fire fighting departments varies, and fire fighting foams containing PFOS are usually less used.
Airports	Limited quantities stored	Airports do not have stationary fire extinguishing installations with fire fighting foams. The fire fighting foam is used in the fire fighting vehicles and the quantities stored are limited. They have frequent fire drills and the replacement rate of the foam is high.
Petrochemical and other relevant industry	Varies	Use depends on type and size of the industrial installations and fire risk. Most industries consume smaller quantities of fire-fighting foam. But larger chemical enterprises may have large quantities stored.
Armed forces	Depends on type of installations	The use of fire fighting foams containing PFOS in military areas depends highly on the type of installations and the fire risk. Access to information is usually very limited.
Car parks	Large quantities	High quantities of stored fire fighting foams containing PFOS have been reported from underground parking areas.
Ships and ferries	Smaller quantities	It is less common to use fire fighting foams containing PFOS or its related substances in ships and ferries, although some tank ship companies have reported that some of their ships store smaller quantities on board.
Tank farms	Large quantities	Large quantities of fire fighting foams are stored at tank farms, and many of them use fire fighting foams containing PFOS. The consumption is less than at offshore installations because of less frequent fire drills.
Onshore gas terminals, installations for gas and oil extraction, oil refineries	Large quantities	Large quantities of fire fighting foams are stored at petroleum installations on shore, and many of them use fire fighting foams containing PFOS. The consumption is less than at offshore installations because of less frequent fire drills.
Offshore installations and mobile rigs	Large quantities	Offshore installations often use large quantities of fire fighting foams containing PFOS, and have larger quantities stored at the platforms in a limited space. There are large variations between platforms in consumption per year, depending on the frequency of fire drills and if they use and release fire fighting foams when testing the fire safety equipment. Smaller quantities of foams are stored at mobile rigs and are usually kept at the helicopter deck.

Today most fire fighting foams are manufactured without PFOS, which has been replaced by fluorochemical/telomers based on a perfluorohexane (C6) chain. In spite of a reduced production in many regions, there are still significant amounts of fire-fighting foams containing PFOS stored, and as fire-fighting foams have a long shelf life (10–20 years or longer), PFOS-containing fire fighting foams may still be used for some time around the world in actual accidental fires. In addition, some regions have reported that fire fighting foams with PFOS are still manufactured in high quantities, and that they were phased in during the 1990s as an alternative to halones, an ozone depleting compound. Newer brands manufactured by Chemguard do not contain PFOS or its related substances. 3M phased out its manufacture of fire fighting foams with PFOS (3M™ Light Water™ foam agents - AFFF or AFFF-ATC) in 2003.

2.6.14.11 Aviation hydraulic fluids

Hydraulic oils containing PFOS have been used as an anti-erosion additive in civil and military airplanes since the 1970s to prevent evaporation, fires and corrosion (UNEP, 2010b). Hydraulic fluids are necessary to transfer the break pressure to the breaking system of the tyres. PFOS is added to inhibit erosion (and to control damages) of mechanical parts of hydraulic systems such as servo valves that are used in aircraft. The lower corrosion effect appears by altering the electrical potential at the metal surface and preventing its electrochemical oxidation (DEFRA, 2004). Hydraulic fluids becoming waste are down-cycled and handled by physical chemical treatment to generate a new product by oil recycling companies or incinerated in specialized treatment facilities (EU, 2011).

2.6.14.12 Insecticides

N-Ethyl perfluorooctane sulfonamide (EtFOSA) is on the list of registered chemicals for use by farmers and grain merchants in several developing countries. The IUPAC name is 1-octanesulphonamide-N-ethyl-1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro, and the substance is also sometimes called sulfluramid. EtFOSA is used both as a surfactant and an active substance in insecticide products used in tropical areas such as Brazil against termites, cockroaches and other insects. It is registered in some developing countries for producing bait to control leaf-cutting ants in sugar plantations. According to information from the OECD (2006) survey, the substance has been used in insecticides at a concentration of 0.01-0.1% at an annual volume of up to 17 tonnes.

2.6.14.13 Stockpiles, waste and contaminated sites

To develop the inventory of practices employed in the management of PFOS waste, stockpiles and contaminated sites, a wide range of stakeholders must be contacted. These include stakeholders involved in the production and use of PFOS applications, as well as waste management authorities and the different operators of waste management situated across the country. There is a need for an environmental waste strategy for waste containing PFOS in the future, and this is an important part of the NIP and the action plan for PFOS. Important waste fractions are discussed in the next sections.

2.6.14.14 Stockpiles

For countries; phasing out the use and production of PFOS, the best strategy to avoid considerable pollution would be to collect and destroy stocks of PFOS instead of using them. Used chemical formulas and galvanic baths could have been stockpiled, and thus need to be collected and destroyed in an environmentally sound manner. This requires good waste treatment facilities for hazardous waste that meet BAT and BEP requirements.

The issue of stockpiles is very important in developing countries because excess PFOS from local oil production and imported from developed countries is stored for further use. For example, in most developing countries of the ECOWAS sub-region, the potential sites for stockpiles of PFOS and its derivatives are oil industry facilities and airports, warehouses and storage facilities of chemical importers. There can also be stockpiles at mines. The use of PFOS in the mining and oil industry in developed countries is most likely phased out. However, large stockpiles of fire fighting foams locally stored at production sites for oil and gas facilities and at airports are important targets during the inventory. Stockpiles with aviation hydraulic fluids at the airports and stockpiles of fire fighting foam agents at industrial sites are also prioritized targets of the inventory. It is important that they are managed in an environmentally sound manner when identified.

2.6.14.15 Waste from treatment of effluents

With the use of PFOS in industries, direct releases to the surface and groundwater can occur at the facilities. If PFOS is removed by water treatment systems, sludge can be contaminated, which eventually might be used as bio solids or deposited in the environment. In many countries the PFOS residues from chrome plating follow the wastewater and end up in sewage sludge, which is sometimes used as fertilizer for agricultural soil. This means a large share of the PFOS used probably ends up in the environment, confirmed by high levels of PFOS recently found in agricultural soils in those countries. Wastes from oil and mining industries can be important in developing countries if treated in incinerating plants with the remnants ending up in landfills and dumpsites.

2.6.14.16 Waste from consumer articles containing PFOS

Application of PFOS could result in bio solids and sewage sludge from municipal treatment plants containing PFOS. Articles like textiles, carpets, furniture and paint containing PFOS have in the past been dumped at landfills or dumpsites. Carpets can represent a huge amount of contaminated waste, depending on the age of the carpets and if they are regularly re-impregnated at homes and institutions. A strategy for collecting and managing this waste is important in the development of the action plan for PFOS.

Developing countries are already faced with many challenges in coping with old PFOS stockpiles and dumps, and do not have appropriate technology or capacity to manage and destroy PFOS. These PFOS-containing materials shall be exported to countries with appropriate destruction capacity or, alternatively, environmentally sound management could be established to limit environmental releases.

2.6.14.17 Contaminated sites

All sites where PFOS has been used can be considered as potential PFOS-contaminated sites. Landfills and dumpsites that are scattered all over the major cities have to be considered as PFOS-contaminated sites as a considerable portion of PFOS substances and precursors are contained within consumer goods and end up in household wastes. PFOS-containing fire fighting foam used in airports, mines, oil and gas drilling, refineries, industrial sites, military installations and large power plants including fire sensitive installations that have frequent fire fighting practice. The release and waste from PFOS used in oil extraction operations could result in PFOS-contaminated sites. In insecticide application, any facilities and larger areas where sulfluramid (a PFOS precursor) was applied as abait for ants and cockroaches are potential contaminated sites. In addition, there could be a deposit of PFOS-containing materials in landfills and dump sites and PFOS-containing bio solids in agricultural lands.

CHAPTER 3: ANALYSIS OF CURRENT SITUATION IN S. AFRICA TEN (POPS) NEW CHEMICALS LISTED UNDER THE STOCKHOLM CONVENTION

3.1 Introduction

The South African government has recognized chemical hazards as a priority problem particularly the management of chemicals under Chapter 19 Agenda 21 of the Stockholm Convention. In South Africa, the Stockholm Convention is implemented by the South African Government through the Department of Environmental Affairs (DEA), in consultation with various other departments such as Departments of: Agriculture Forestry and Fisheries, Water Affairs, International Relations, Trade and Industries, Science and Technology, Health and Custom and Excise to mention but few. In addition, several non-governmental organisations, industry bodies and parastatal organisations are consulted on the implementation of the Convention through a national chemicals stakeholder coordination committee. The ultimate goal of DEA's call for inventory of ten new POPs in South Africa was geared towards fulfilling the following:

➢ The Bill of Rights as stated in the South African Constitution with specific emphasis on the environmental right. The Bill of Rights states, *inter alia*, that:

"Everyone has the right –

(a) To an environment that is not harmful to their health or well-being; and

(b) to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that-

a. prevent pollution and ecological degradation;

b. promote conservation; and

c. secure ecologically sustainable development and use of natural;

d. resources while promoting justifiable economic and social development."

The South African State has a duty to give effect to this right by implementing measures to protect the environment for present and future generations. Examples of such measures would be those for regulating the existence, and use of POPs in South Africa. The Constitution also sets out the rights and obligations of the legislative and executive arms of government in adopting international agreements.

3.2 Industry structure and application of the listed chemicals in South Africa

In South Africa, the chemical industry is relatively well developed with a strong upstream manufacturing sector for base chemicals. It is estimated that in 2008, the chemical industry contributed about 5% to South Africa's GDP. However, the downstream sector is still highly dependent on the importation of many speciality chemicals, including agricultural chemicals. Available information indicates that the POP chemicals are not manufactured locally and are, therefore, imported into the country where they are then blended or formulated for their respective end-user sectors. Thus, the local blenders and formulators, especially in the agricultural application are the largest part of the supply chain structure. The main end-users of POPs chemicals are agricultural and industrial sectors. Agricultural end-users include commercial and subsistence farmers and the industrial applications consist of the following end-user groups: flame retardants and coatings and wood preservation.

3.1.1 POPs in agricultural sector

Chemicals have been used extensively by various sectors in South Africa for many years. South Africa is also a manufacture of chemicals and several chemical formulators are registered and operate in the country. The chemicals used, manufactured and still formulated include POPs chemicals. The use and manufacture of POPs chemicals could have and may still contribute to releases of POPs into the environment and have lead to contamination of sites and the generation of wastes and stockpiles containing POPs.

The POPs chemicals imported either as active ingredients for inclusion into agricultural products, namely crop protection and some animal health products by local formulators or as components within fully manufactured products. POPs chemicals used in crop protection products are purchased by both the subsistence and commercial farming sectors as well as by publicly funded initiatives for agriculture. Commercial farming does, however, account for a significantly larger share of consumption. The management of stockpiles of crop protection chemicals (pesticides) is not well organized compared with the industrial sector where all manufacturers already have measures in place for dealing with waste, effluents and chemical by-products. The key role players in this industry include:

- **Local formulators**: These import active ingredients and other raw materials to formulate crop protection or animal health products for sale to the local market;

➢ **Traders, importers or distributors**: These source either raw materials, semi-finished products or final products for distribution to manufacturers or end-users and

➢ **Finished product suppliers**: These manufacture products outside of South Africa and import these into the country.

An overview of the supply chain of pesticides in agricultural sector in South Africa is shown in Figure 3-1.

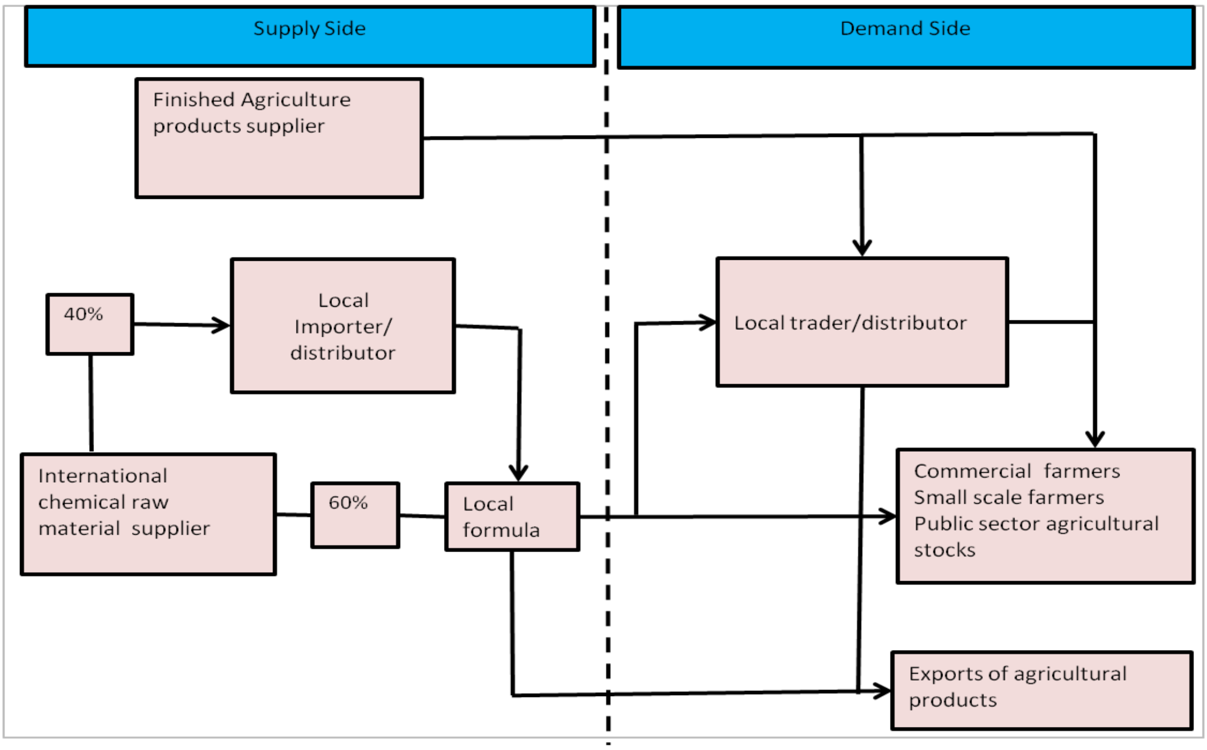

Figure 3-1: Supply chain of pesticides in agricultural sector in South Africa (Frost & Sullivan, 2010)

3.1.2 POPs in industrial sector (Flame retardants)

In South Africa, there are little or no manufacturing of flame retardants. Therefore, most of the flame retardants used in the country are imported. The largest source of the POP flame retardants results from the imports of fully manufactured products such as textiles, foams and electronics that have been treated with flame retardants. The key role players include:

➢ **Importers and distributors**: These import products that already contain flame retarded and importers of flame retardant chemicals;

➢ **Manufacturers**: These import flame retardant chemicals and apply them in the manufacture of products such as textiles, plastics and foams which are supplied to end-users or fabricators; and

- **Fabricators**: These purchase materials containing flame retardant chemicals and fabricate them into products for various end-users.

The supply chain structure of flame retardants industry in South Africa is given in Figure 3-2.

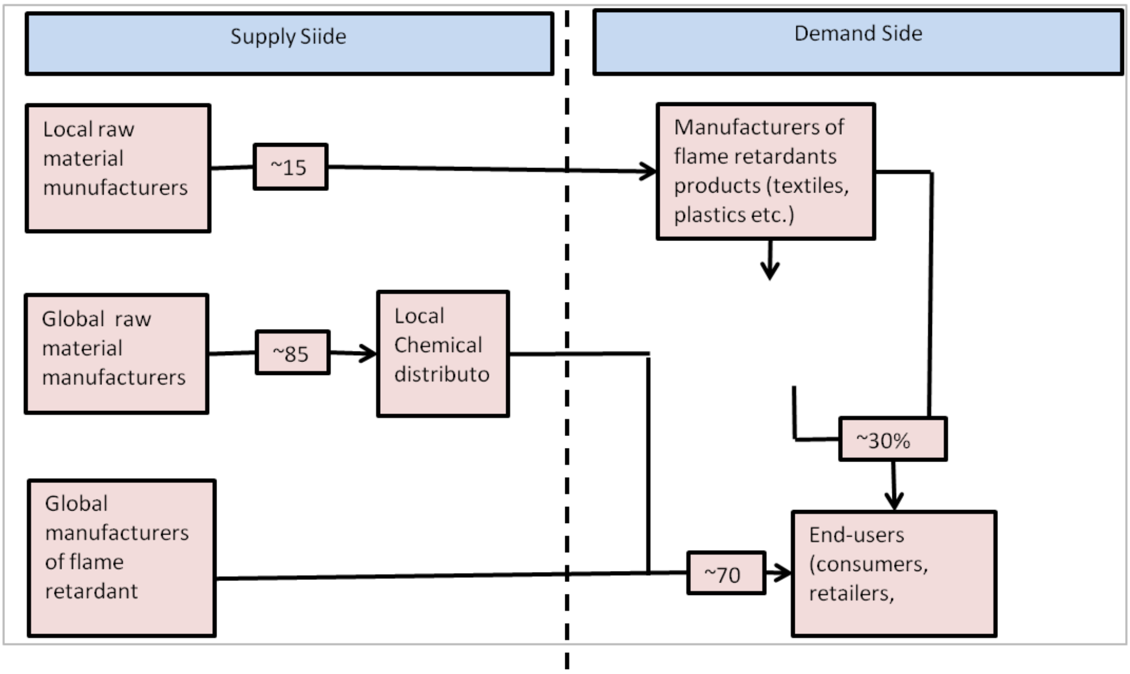

Figure 3-2: Supply chain structure of flame retardants industry in South Africa (Frost & Sullivan, 2010)

3.1.3 POPs in industrial sector (coatings, paints and wood preservation)

The final end-user sector for these chemicals is the coatings, paint and wood preservations sector. South Africa has a well established coatings manufacturing sector which contributes to 0.2% of GDP. Of this market, industrial coatings, which include marine and wood preservation coatings, account for 23%. The key participants include:

- **Importers and distributors**: These import paints, coatings or wood preservation products and importers of raw materials for the paint manufacturers and wood preservation industry and

- **Manufacturers**: These manufacture paints, coatings and wood preservation products using local and imported raw materials and active ingredients and supply these to end-users.

CHAPTER 4: LEGAL FRAMEWORK AVAILABLE IN SOUTH AFRICA THAT ARE USED TO CONTROL AND MANAGE CHEMICALS

4.1 Introduction

South Africa is a party to various multilateral environmental agreements which deal with chemicals management issues namely; the Basel Convention on the Control of Trans-boundary Movement of Hazardous Waste, the Rotterdam Convention on the Prior Informed Consent Procedures for Certain Hazardous Chemicals and Pesticides in International Trade, and the Montreal Protocol on Substances that Deplete the Ozone Layer. South Africa also played a leading role in the development of the Strategic Approach to International Chemicals Management (SAICM) and contributes to its Quick Start Programme.

The legal frameworks which are used to address the management of chemicals in South Africa are spead in various South African government departments. Each regulation is under an appropriate department which is capable of managing it and see to it that such a regulation is enforced. The regulations are spread across the departments of Environmental Affairs (DEA)-environmental related regulations, Department of Defence and War Veterans (DDWV)-chemical warfare related regulations, Department Water Affairs (DWA)-water related regulations, Department of Health (DoH)- health related chemicals; Department of Agriculture, Food and Fisheries (DoAFF)-agriculture related regulations, Department of Mineral Resources (DMR)-chemicals of industrial application and others.

4.2 The legal frame works available in South Africa used to control chemicals

There are framework legislations that address chemical management in South Africa and these include:

- Constitution of the Republic of South Africa Act (Act No. 108 of 1996);
- National Environmental Management Act (Act No. 107 of 1998);
- Environmental Conservation Act 73 of 1989 (Act repealed);
- National Laws on Hazardous Chemicals;
- Atmospheric Pollution Prevention Act 45 of 1965 (APPA), and the National Environmental Management Air Quality Act 39 0f 2004 (AQA**);**
- Customs and Excise Act 91 of 1964;
- Fertilizers, Farm feeds and Agricultural Remedies and Stock Remedies Act and Regulations No 36 of 1947**;**

- Hazardous Substances Act No 15 of 1973;
- Health Act 63 of 1977;
- International Trade Administration Act 71 0f 2002 (ITA Act);
- National Environmental Management Biodiversity Act 10 of 2004 (the Biodiversity Act);
- National Environmental Management: Waste Management Act No. 59 of 2008;
- Occupational Health and Safety Act 85 of 1993 (OHSA), and Regulations;
- Promotion of Access to Information Act 71 of 2002 (PAIA):
- National Water Act (Act No. 36 of 1998);
- Non Proliferation of Weapons of Mass Destruction Act (Act No. 87 of 1993);
- Drugs and Drug Trafficking Act (Act No. 140 of 1992); and

4.2.1 The Constitution

The Constitution of the Republic of South Africa is the supreme law of South Africa and it governs and is superior to all other laws in the land. The law states that everybody has the right:

- to an environment that is not harmful to their health or well-being; and
- to have the environment protected for the benefit of present and future generations, through reasonable legislative and other measures that:
    - prevent pollution and ecological degradation;
    - promote conservation and
    - Secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.

The President of the Republic of South Africa is the custodian of the provisions of the constitution through various measures that ensure that the intentions of the constitution are realized in South Africa, including environmentally sound management of hazardous chemicals. The Constitution on the subject of environment emphasised the need for balance between the prevention of pollution and ecological degradation and promotion of sustainable development.

4.2.2 National Environmental Management Act and Regulations (NEMA)

The Department of Environmental Affairs (DEA) is the custodian of the National Environmental Management Act (NEMA). Through its principles for environmental management and the duty of care, NEMA is meant to address the right to an environment that is not harmful to the health or well being of organisms as enshrined in the South African Constitution. NEMA enables the Minister of Environmental and Water Affairs (EWA) to draft Regulations to accommodate and adequately capture the provisions of the Multilateral Environmental Agreements that South Africa is a Party to, including the identification of any measures in need of environmental authorization.

Most NEMA principles, to a larger extent, capture the essence of some of the provisions of the Rotterdam Convention:

- for the participation of all interested and affected parties in environmental governance; the Rotterdam Convention promotes a multi-stakeholder approach for its effective implementation;
- that the social, economic and environmental impact of activities must be considered; the Rotterdam Convention requires that Parties indicate any environmental, human health, and socio-economic implications when a proposal of a Final Regulatory Action to either ban or severely restrict a hazardous chemical is submitted to the Secretariat for consideration through the CRC;
- the rights of workers to refuse work that is harmful to human health or the environment must be respected and protected; the Rotterdam Convention promotes the sharing of information on the management of chemicals including its use through the PIC procedure as one of its tools and also through the provision of Draft Guidance Documents (DGD), and its acknowledgement and collaboration with the Stockholm and the Basel Conventions regarding the environmental sound disposal of hazardous chemicals to protect the environment;
- that access to information must be provided; sharing of information is at the core of the essence of the Rotterdam Convention through its promotion of the DNA's continuous engagement with multi-stakeholders, PIC Procedure, DGDs, PIC circular and other additional information provided through the convention's website, and
- that global and international responsibilities relating to the environment must be discharged in the national interest; the Rotterdam Convention facilitates the transfer of skills for Parties to effectively implement the provisions of the convention through its

workshops that are held at national and regional levels to share experiences and to assist the development of implementation frameworks through multi-stakeholder engagements.

4.2.3 Environmental Conservation Act

The Environmental Conservation Act (ECA) has been promulgated to address the effective protection and controlled utilization of the environment. It enables that the Government Institutions to issue directives to persons that carry out activities that cause damage to the environment; improper management of chemicals could cause damage to the environment, and hazardous pesticide formulations may also cause damage on the environment even when directions on use are followed. However, this Act has now been repealed and most of its functions are covered under, The National Environmental Management Waste Act of 2008.

4.2.4 National Laws on Hazardous Chemicals; listed in alphabetic order:

South Africa has promulgated several laws that aim or partly aim at addressing the issue of hazardous chemicals management and these are:

4.2.4.1 Atmospheric Pollution Prevention Act 45 of 1965 (APPA), and
the National Environmental Management Air Quality Act 39 0f 2004 (AQA):

Although the Rotterdam Convention does not specifically refer to hazardous chemical emissions, its primary objective of protecting human health and the environment (which includes the atmosphere) during the international trade in hazardous chemicals and its acknowledgement and collaboration with the Stockholm and the Basel Conventions, necessitates the reference to the Atmospheric Pollution Prevention Act (APPA) and the National Environmental Management Air Quality Act (AQA); with DEA being the custodian of these Acts.

The Atmospheric Pollution Prevention Act (APPA) enables for the prevention of the pollution of the atmosphere. Hazardous Chemical substances could be used during the undertaking of second schedule substances as listed in the Act. The National Environmental Management Air Quality Act (AQA) was promulgated to reform the legislation on air quality so as to protect the environment by making provisions for the prevention of pollution and ecological degradation. When the repeal provisions are enforced, APPA is to be repealed by

AQA. The provisions of AQA such as the air management measures include the declaration of priority areas; listing of activities; controlled emitters and fuels, and offensive odours, *inter alia*. Activities may be regarded as "controlled emitters" by the Minister or MECs if they result to atmospheric emissions which through ambient concentrations, bioaccumulation, deposition or in any other way, present a threat to the health or the environment or are believed to present such a threat. Due to their chemical properties, the chemicals that are listed in Annex III of the Rotterdam Convention that are used in the activities that are regarded as "control emitters" could be regulated under this Act.

4.2.4.2 Customs and Excise Act 91 of 1964:

The custodian of the Customs and Excise Act is the South African Revenue Services (SARS). The Act prohibits and controls the import, export, manufacture or use of certain goods. SARS has developed a list of prohibited and restricted substances that can be imported and exported. The hazardous chemicals listed in Annex III of the Rotterdam Convention are subject to Prior Informed Consent and some of these have been banned in various countries, even in South Africa. Should the Annex III Chemicals be listed in prohibited and restricted list, it could be used as an instrument to strengthen the implementation of the provisions of the Rotterdam Convention, and the compliance and monitoring of the hazardous chemicals listed in Annex III of the Convention.

4.2.4.3 Fertilizers, Farm feeds and Agricultural Remedies and Stock Remedies Act and Regulation No. 36 of 1947:

The National Department of Agriculture is the custodian of the Fertilizers, Farm feeds and Agricultural Remedies and Stock Remedies Act (FFAS Act). The FFAS Act provides for the appointment of a Register of Fertilizers, Farm Feeds and Agricultural Remedies; for the registration of fertilizers, farm feeds, agricultural remedies, stock remedies, sterilizing plants and pest control operators, to regulate or prohibit the importation, sale, acquisition, disposal or use of fertilizers, farm feeds, agricultural remedies and stock remedies; to provide for the designation of technical advisers and analysts; and to provide for matters incidental thereto. "Agricultural remedies" include chemical substances, biological remedies or any mixture or combination of any substance or remedy intended or offered to be used for, among others, pest destruction or control, but exclude any chemical substances, biological remedy or other remedy in so far as it is controlled under the Hazardous Substance Act. "Stock remedies" are substances intended or offered to be used in connection with animals for the diagnosis, prevention, treatment or cure of any disease, infection or unhealthy condition, among other things, excluding substances in so far as they are controlled under the Medicines and Related Substances Control Act 101 0f 1965.

Furthermore, and in line with information exchange of the Rotterdam Convention, the FFAS Act directs the owner or person administering an agricultural remedy to inform persons of the purpose and the registered name of the substance before it is administered. Most of the hazardous chemicals of international trade that are listed in Annex III of the Rotterdam Convention are pesticides; the trade of which is increased due to demand on the increase of food production, more so now that the world is faced with drastic changes in climatic conditions that negatively affect crop yield.

4.2.4.4 Hazardous Substances Act No 15 of 1973:

The Department of Health is the custodian of the Hazardous Substance Act. The Hazardous Substance Act provides for the control of substances which may cause injury or ill-health or death of human beings by reason of their toxic, corrosive, irritant, strongly sensitizing or flammable nature, and for the control of certain electronic products; to provide for the division of such substances or products into groups in relation to the degree of danger; to provide for the prohibition and control of the importation, manufacture, sale, use, operation, application, modification, disposal or dumping of such substances and products; and to provide for matters connected therewith. The Act provides for four groups of hazardous substances and makes reference to the South African National Standards (SANS) for the Group I and II hazardous substances, with hazardous substances as listed on the Rotterdam Convention falling within these Groups. Notwithstanding that Polychlorinated Biphenyls (PCBs) that ordinarily would be under Group II, but due to the fact that they are also found in old electrical transformers which fall under Group III substances; this therefore, infers that PCBs could to some extent be regulated under Group III hazardous substances when in old electronic products such as old electric transformers.

4.2.4.5 Health Act 63 of 1977:

The Department of Health is the custodian of the Health Act. The Act controls the handling, use and application of chemical substances that have the potential to cause adverse effects to human and animal health unless immediately remedied, and to which the provisions of the

APPA are not applicable. This could be applicable to the production and the use of hazardous chemicals that could pose adverse effects to human health; the latter being more relevant to the provisions of the Rotterdam Convention.

4.2.4.6 International Trade Administration Act 71 of 2002 (ITA Act):

The Department of Trade and Industry (**the dti**) is the custodian of the International Trade Administration Act. 58 Previously International Trade Administration Commission (ITAC) as an agency of **the dti** however currently the Economic Development Department oversees work of International Trade Administration Commission (ITAC).

ITAC's core functions are customs tariffs, trade remedies such as anti-dumping and import and export control. ITAC provides technical advice to Economic Development Department and **the dti**. ITAC has a list of chemicals that can be imported or exported and specific conditions attached to the importation or exportation of such chemicals. Currently, the PIC procedure is only administered by the DNA at DEA; involvement of ITAC to promote involvement of the chemical industry in observing and applying the PIC when exporting the hazardous chemicals from South Africa to other countries in line with the provisions of the Rotterdam Convention, would improve compliance and monitoring.

4.2.4.7 National Environmental Management Biodiversity Act 10 of 2004 (the Biodiversity Act):

The Department of Environmental Affairs (DEA) is the custodian of the National Environmental Management Biodiversity Act 10 of 2004 (the Biodiversity Act). The Act regulates the use or application of chemical substances to the environment as pest control which may result in either the death or poisoning of non-target species. The intention of the Biodiversity Act is to protect South Africa's biodiversity, and that includes fauna and flora. It enables the Minister to identify any activity that may present threat to the environment in an ecosystem that is threatened or in need of protection, as a "threatening process" for which an Environmental Impact Assessment (EIA) is required. Lack of effective implementation of the provisions of the Rotterdam Convention when trading in hazardous chemicals by the DNA and primarily industry and users of these chemicals could threaten vulnerable ecosystem, as at times economic benefits outweigh the primary need to be compliant.

4.2.4.8 National Environmental Management: Waste Management Act No. 59 of 2008:

The National Environmental Management Waste Act has been enacted to reform the law regulating waste management in South Africa in order to protect health and the environment by providing reasonable measures for the prevention of pollution and ecological degradation and for securing ecologically sustainable development; to provide for institutional arrangements and matters and planning matters; to provide for national norms and standards regulating the management of waste by all spheres of government; to provide for specific waste management measures; to provide for the licensing and control of waste management activities; to provide for the remediation of contaminated land; to provide for the national waste information system; to provide for compliance and enforcement; and to provide for matters connected therewith.

The identification of synergies and collaboration of the Rotterdam Convention with the Stockholm and the Basel convention in promoting holistic management of chemicals necessitates that the cradle to grave approach be applied when the international trade in chemicals occurs; this including the safe disposal of containers of the hazardous chemicals after the chemicals have been used, as these may pose threat to human health and the environment. The provisions of the Waste Act of 2007 promote sharing of responsibility throughout the life cycle of a product and an environmentally sound disposal of wastes.

4.2.4.9 Occupational Health and Safety Act 85 of 1993 (OHSA), and Regulations:

The custodian of the Occupational and Safety Act (OHSA) is the Department of Labour. The Act requires employers to maintain a working environment that is without risk to the Health of employee and must ensure that employees' exposure to hazardous chemicals is prevented or adequately controlled. Trade in hazardous chemical substances may present a hazard to the employees involved in the whole trade chain; the health of such employees can be protected through this Act. The Act provides for the control of substances which may cause injury or ill-health to or death of human beings by reason of their toxic, corrosive, irritant, strongly sensitising or flammable nature or generation of pressure in certain circumstances, and for the control of certain electronic products; to provide for the division of such substances or products into groups in relation to the degree of danger; to provide for the prohibition and control of the importation , manufacture, sale, use, operation, application, modification, disposal or dumping of such substances and products; and to provide for matters connected therewith.

4.2.4.10 Promotion of Access to Information Act 71 of 2002 (PAIA):

The Promotion and Access to Information Act was promulgated to address the constitutional right of access to information held by another person that is required for the exercise or protection of rights. According to this Act, a request for a record of a private body may not be refused insofar as it consists of information about the results of any product or environmental testing or other investigation supplied by a third party or the results of such testing or investigation carried out by or on behalf of a third party, and its disclosure would reveal a serious public safety or environmental risk. Sharing of information with other Parties through the PIC procedure, PIC circular, and the DGDs promotes prevention of chemical hazards during the trade of hazardous chemicals, and this Act can be used to promote better sharing of information between Parties.

4.2.4.11 The National Water Act 36 of 1998:

The Department of Water Affairs is the Custodian of the Water Act. The Act enables the commanding liability for the pollution of water resources; which could occur if proper measures are not put in place when trading in hazardous chemicals. To promote the implementation of the provisions of the Rotterdam Convention regarding the sharing of responsibility and the protection of the environment, in this case, water being part of the environment, this Act can be used. The Act provides regulations for prevention and monitoring the use of chemical substances with potential to pollute water resources which could be either in the form of groundwater or surface water in rivers and dams.

4.2.4.12 Non Proliferation of Weapons of Mass Destruction Act (Act No. 87 of 1993):

the dti is the custodian of the Non Proliferation of Weapons of Mass Destruction Act (Act No. 87 of 1993) and falls under the International Trade and Economic Development Division. The Minister may, on the recommendation of the Council, whenever he/she deems it necessary or expedient in the public interest, by notice in the *Gazette* declare goods which may contribute to the design, development, production, deployment, maintenance or use of weapons of mass destruction, to be controlled goods. The Minister may in such notice -

- prohibit the import, export, re-export or transit of such goods;
- limit or control the import, export, re-export or transit of such goods, and
- determine that the import, export, re-export or transit of such goods may only take place under a permit issued by the Council;
- make the import, export, re-export or transit of such goods subject to end use requirements;
- require a declaration to the Council in accordance with the provisions of an international convention, treaty or agreement with regard to the manufacture, procurement in any manner, use, operation, stockpiling, maintenance, transport, import, export, transit or re-export of such goods;
- prohibit the manufacture, procurement in any manner, use, operation, stockpiling, maintenance, transport or disposal by any means of such goods;
- make the manufacture, procurement in any manner, use, operation, stockpiling, maintenance, transport or disposal by any means of such goods, subject to a permit issued by the Council.

The Act goes further to define “chemical warfare agent” as any chemical, regardless of the origin or method of production thereof, which poses a real or potential risk of being used as a weapon of mass destruction, and which through the specific application of its chemical action on life processes can cause death, temporary incapacity or permanent harm to humans, animals or plants. To promote the implementation of the provisions of the Rotterdam Convention regarding the use of hazardous chemicals and their proper management in order to reduce environmental and human impact, this Act can be used to address the issue of hazardous chemicals in order to protect human health and the environment from potential harm.

4.2.4.13 Drugs and Drug Trafficking Act (Act No. 140 of 1992):

This Act stipulates that no person shall manufacture any scheduled substance or supply it to any other person, knowing or suspecting that any such scheduled substance is to be used in or for the unlawful manufacture of any drug. The Act goes further to define drug as any dependence-producing substance, any dangerous dependence-producing substance or any undesirable dependence-producing substance. Considering the fact that a number of the chemicals and pesticides can have some dependence effect, this Act is very much in line with the Rotterdam Convention on sound management of chemicals and pesticides.Table 4-1 shows the relevant regulations for the control of the listed chemicals.

Table 4-1: Relevant regulations in South Africa that addresses the listed chemicals

CHEMICAL	REGULATION	STATUS
CHLORDECONE (KEPONE)	**Hazardous Substances Act No 15 of 1973** This Act provides for the control of substances which may cause injury or ill-health or death of human beings due to their toxic, corrosive, irritant, strongly sensitizing or flammable nature. In addition, to provide (1) for the division of such substances or products into groups in relation to the degree of danger, (2) for the prohibition and control of the importation, manufacture, sale, use, operation, application, modification, disposal or dumping of such substances and products.	Prohibited in 1971 (MAFF, 2002)
ENDOSULFAN	**Fertilizers, Farm feeds and Agricultural Remedies and Stock Remedies Act No 36 of 1947** This Act regulates the registration of fertilizers, farm feeds, agricultural remedies, stock remedies, sterilizing plants and pest control operators, in order to regulate or prohibit the importation, sale, acquisition, disposal or use of fertilizers, farm feeds, agricultural remedies and stock remedies. **Department of Health** - Regulation 452 of 25 March 1977. Government Regulations that address the management of chemicals and pesticides in South Africa.	Prohibited as from October 2012 in terms of acquisition, disposal, sale or use of an agricultural remedy containing endosulfan. GN No 853
HEXABROMOBIPHENYL	**Hazardous Substances Act No 15 of 1973** This Act provides for the control of substances which may cause injury or ill-health or death of human beings due to their toxic, corrosive, irritant, strongly Sensitizing or flammable nature. In addition, to provide (1) for the division of such substances or products into groups in relation to the degree of danger, (2) for the prohibition and control of the importation, manufacture, sale, use, operation, application, modification, disposal or dumping of such substances and products.	Not prohibited by any regulation
HEPTABROMODIPHENYL ETHER	**Hazardous Substances Act No 15 of 1973** This Act provides for the control of substances which may cause injury or ill-health or death of human beings due to their toxic, corrosive, irritant, strongly sensitizing or flammable nature. In addition, to provide (1) for the division of such substances or products into groups in relation to the degree of danger, (2) for the prohibition and control of the importation, manufacture, sale, use, operation, application, modification, disposal or dumping of such substances and products.	Not prohibited by any regulation

ALPHA HEXACHLOROCYCLOHEXANE	**Fertilizers, Farm feeds and Agricultural Remedies and Stock Remedies Act No 36 of 1947** This Act regulates the registration of fertilizers, farm feeds, agricultural remedies, stock remedies, sterilizing plants and pest control operators, in order to regulate or prohibit the importation, sale, acquisition, disposal or use of fertilizers, farm feeds, agricultural remedies and stock remedies	Prohibited as stock remedy in June 1987 (GG 10739) and as agricultural remedy in May 2009 (GG No R. 592)
BETA HEXACHLOROCYCLOHEXANE	**Fertilizers, Farm feeds and Agricultural Remedies and Stock Remedies Act No 36 of 1947** This Act regulates the registration of fertilizers, farm feeds, agricultural remedies, stock remedies, sterilizing plants and pest control operators, in order to regulate or prohibit the importation, sale, acquisition, disposal or use of fertilizers, farm feeds, agricultural remedies and stock remedies	Prohibited as stock remedy in June 1987 (GG 10739) and as agricultural remedy in May 2009 (GG No R. 592)
LINDANE	**Fertilizers, Farm feeds and Agricultural Remedies and Stock Remedies Act No 36 of 1947** This Act regulates the registration of fertilizers, farm feeds, agricultural remedies, stock remedies, sterilizing plants and pest control operators, in order to regulate or prohibit the importation, sale, acquisition, disposal or use of fertilizers, farm feeds, agricultural remedies and stock remedies	Prohibited as stock remedy in June 1987 (GG 10739) and as agricultural remedy in May 2009 (GG No R. 592)
PENTACHLOROBENZENE (PeCB)	**Fertilizers, Farm feeds and Agricultural Remedies and Stock Remedies Act No 36 of 1947** **Hazardous Substances Act No 15 of 1973**: The Act No 15 of 1973 provides for the control of substances which may cause injury or ill-health or death of human beings due to their toxic, corrosive, irritant, strongly sensitizing or flammable nature. In addition, to provide (1) for the division of such substances or products into groups in relation to the degree of danger, (2) for the prohibition and control of the importation, manufacture, sale, use, operation, application, modification, disposal or dumping of such substances and products.	Not prohibited by any regulation
PERFLUOROOCTANE SULFONIC ACID (PFOS) ITS SALTS & PERFLUOROOCTANE SULFONYL FLUORIDE (PFOS-F)	**Hazardous Substances Act No 15 of 1973** This Act provides for the control of substances which may cause injury or ill-health or death of human beings due to their toxic, corrosive, irritant, strongly sensitizing or flammable nature. In addition, to provide (1) for the division of such substances or products into groups in relation to the degree of danger, (2) for the prohibition and control of the importation, manufacture, sale, use, operation, application, modification, disposal or dumping of such substances and products.	Not prohibited by any regulation
PENTABROMODIPHENYL ETHER (TETRABROMODIPHENYL ETHER, PENTABROMODIPHENYL	**Hazardous Substances Act No 15 of 1973** This Act provides for the control of substances which may cause injury or ill-health or death of human beings due to their toxic, corrosive, irritant, strongly sensitizing or flammable nature. In addition, to provide (1) for the division of such substances or products into	Not prohibited by any regulation

ETHER	groups in relation to the degree of danger, (2) for the prohibition and control of the importation, manufacture, sale, use, operation, application, modification, disposal or dumping of such substances and products.	

As can be seen in Table 4-2, that endosulfan is the most recent POPs chemical pesticide to be prohibited.

Table 4-2: Listed chemicals that have been prohibited in South Africa

I. D	Substance	Category	Effective date	Status	Regulation/Gazette
1	Chlordecone (kepone)	Pesticide		The use of chlordecone was prohibited in 1971	A guide to the control of plant pests 2002 (Appendix 1)
2	Gamma-BHC (lindane).	Pesticide	30-06-1987	All stock remedy registrations were withdrawn in 1971.	Gazette No: R 1061 of 15 May 1987, Government Gazette.R.1296 of 5 December 20 2008(Appendix 1); 22 No. 32254 GOVERNMENT GAZETTE, 29 MAY 2009 No. R. 592 29 May 2009
3	Alpha-Hexachlorocyclohexane and beta-Hexachlorocyclohexane (mixed isomers)	Pesticide	25-02-1983	prohibited in 1987	Gazette No: R 1061 of 15 May 1987(Appendix 1)

4	Endosulfan	Pesticide	October 2012	Registration on fodder crops was suspended in 1970 and banned in 2012	Notice 853 (Appendix 1)

4.3 Import and export of listed chemicals in South Africa

For the POP-chemicals under review, South Africa appears to be highly dependent on imports. The trade data discussed in this section is based on statistics from SARS and UN Comtrade. However, information on some of the POP-chemicals under view seems not to be available. Table 4-3 shows the categories used for the trade analysis as they relate to the list of chemicals under consideration.

Table 4-3: Import and export trade data for the listed chemicals (UN Comtrade, 2013; the dti, 2013)

CHEMICAL	CHEMICAL DESCRIPTION AND HARMONIZED CODE	COUNTRIES	
		IMPORT	EXPORT
Chlordecone	2914.70 Halogenated, sulphonated, nitrated or nitrosated derivatives HS Code: 2914.70.10	No import probably because of the prohibition	No export probably because of the prohibition
Endosulfan	No information found	No information found	No information found
Hexabromobiphenyl	2903.9 Halogenated deriviatives of aromatic hydrocarbons. HS Code: 2903.89.40	China, and Germany	Democratic Republic of Congo,
Heptabromodiphenyl ether	No information found	No information found	No information found
α-	2903.8 Halogenated derivatives of	Germany	No export

hexachlorocyclohexane	cycianic, cyclenic or cycloterpenic hydrocarbons HS Code: 2903.81.20	India	
β-hexachlorocyclohexane	2903.8 Halogenated derivatives of cycianic, cyclenic or cycloterpenic hydrocarbons HS Code: 2903.81.30	Germany India	No export
Lindane	2903.8 Halogenated derivatives of cycianic, cyclenic or cycloterpenic hydrocarbons HS Code: 2903.81.10	Germany and India	No export
Pentachlorobenzene (PeCB)	2903.9 Halogenated deriviatives of aromatic hydrocarbons HS Code: 2903.99.35	India, China and Italy	Zimbabwe, Mauritius and Zambia
Perfluorooctane sulfonic acid (PFOS) its salts & perfluorooctane sulfonyl fluoride (PFOS-F)	2914.70 Halogenated, sulphonated, nitrated or nitrosated derivatives HS Code: 2915.90.10	Republic of Korea, Spain, Japan, USA and India	Zambia, Zimbabwe, Malawi and Mauritius
Pentabromodiphenyl ether (Tetrabromodiphenyl ether,	2909.30 Aromatic ethers and their halogenated, sulphonated, nitrated or nitrosated derivatives HS Code: 2909.30.10 PentaBDE HS Code: 2909.3020 TetraBDE	China, and Germany	Democratic Republic of Congo,

4.4 Current management measures or restrictions for listed chemicals

This section discusses management measures undertaken by both the public and private sectors for current and future management of the chemicals in the South African industries. The established Multi-stakeholder Committee on Chemicals Management (MCCM) driven by DEA and existing regulations or chemicals management initiatives by industry could potentially be leveraged to support the proposed measures by the conventions. Some years ago, African Stockpile Programme (ASP) was embarked on in the agricultural sector. Although the success of this programme is yet to be seen, it is one measure in place for dealing with unused crop protection chemicals. The programme was funded by the World Bank and Croplife International.

Also inventory of pesticides stockpile was conducted in three provinces namely, Gauteng, Limpopo and Western Cape. In 2011, the Association of Veterinary and Crop Associations of South Africa (AVCASA) conducted an inventory on National Retrieval Scheme on behalf of the then National Department of Agriculture, Food and Fisheries to recover unused pesticides in farms or government hands. According to ITA-PEG, a number of electronic and ICT manufacturers have already phased out the application of POP-PBDE in their products.

4.5 Conclusions

- There are legal framesworks in South Africa that are currently used for management of chemicals;
- The Hazardus Chemicals Act appears to be adequate to control the newly listed POP chemicals in the absence of specific legislation on POP chemicals;
- Some management measures have been undertaken by both the public and private sectors for current and future management of POP chemicals in the South Africa's industries.

CHAPTER 5: INVENTORY METHODOLOGY FOR TEN NEW POPs LISTED UNDER THE STOCKHOLM CONVENTION

5.1 Introduction

The development of a national inventory of products and articles requires cooperation with the relevant authority in charge of manufacturers of consumer products, suppliers, retailers and the customs service, as well as other relevant authorities and organizations. It is important to clearly define the responsibility for developing the inventory. The inventory process comprises five steps namely:

- Planning the inventory;
- Choosing data collection methodology;
- Collecting and compiling data from key sectors;
- Managing and evaluating the data; and
- Preparing the inventory report.

5.1.1 Planning the inventory

The first step to consider in developing a national inventory is to define the scope of the inventory and target the national relevant sectors. The inventory requires cooperation with the relevant authority in charge of manufacturers, formulators, importers and exporters of consumer products, suppliers, retailers and the customs service, as well as other relevant authorities and organizations. It is important to clearly define the responsibility for developing the inventory.

Establishment of a Designated National Authority (DNA) whose responsibility is to coordinate the inventory process as well as form a link with stakeholders comprising government departments with a mandate for chemicals and waste management, the national customs service, the private sector, non-governmental organizations (NGOs), and academics and researchers from universities and research institutes working on old and new POPs, waste management and possibly material flows is essential.

The inventory development requires cooperation between relevant government authorities and official agencies, producers, importers and distributors, manufacturers, fabricators, community-based organizations and NGOs, organized labour and trade unions, industrial enterprises, other private-sector organizations, the waste management and recycling sector.

Making contact with stakeholders at the beginning of the inventory exercise can give them a better understanding of its background, scope and objectives and provide them with an opportunity to communicate their views and questions. This initial feedback can help make the inventory more effective by targeting the relevant areas of national use. General tools that were used to identify and contact stakeholders include:

- Telephone interviews;
- Email/Web-based information sourcing;
- Face-to-face interviews;
- Phone books;
- National registers.
- Harmonised code system (HS Code):

Chemical	Harmonised System Code (HS Code)
PFOSF	29.03.39.10
Other PFOS	29.03.39.90
Lindane	29.03.81.10
PeCB	29.03.99.35 etc (See Table 4-3)

During the inventory planning stage, it may be more efficient to contact and consult only a small number of relevant stakeholders such as larger manufacturers, national industrial associations and the customs service. Gap analyses conducted in the evaluation of the initial assessment or the preliminary inventory could result in the need to contact some of these stakeholders again to get more information or identify other stakeholders to be contacted to help fill in the information and data gaps.

Defining the scope of the inventory involves identifying the relevant national sectors to be investigated further. This can be achieved by consulting key stakeholders and paying special attention to the use categories and life cycle stages on:

- Types and quantities of articles containing POPs chemicals;
- Types of articles containing POPs chemicals that are recycled, the possible extent of recycling, and the types of articles produced from recycling;
- Types and quantities of POPs chemicals stockpiles and wastes from former production and use in industries; and
- Locations where activities have occurred that could be potentially contaminated with POPs PBDEs, POP-Pesticides, and PFOS.

The following criteria are important in defining the scope of the inventory:

- Obligations for POPs-PBDEs, Pesticides, PFOS under the Stockholm Convention and
- Objectives of POPs-PBDEs, Pesticides, PFOSA inventory.

The core inventory team was expected to develop a work plan for the inventory, which could be discussed with the stakeholders.

Elements of the plan included:

- Inventory strategy on what needed to be done to identify the sectors;
- Methodologies to be used;
- Activities needed and assignments;
- Resources allocation including responsibility and budget; and
- Timeline and milestones.

Once the inventory planning is concluded, the next step is to choose appropriate methodologies for data collection. The recommended methodology is the tiered approach.

5.1.2 Choosing data collection methodologies

The next step is to choose appropriate methodologies for data collection, using a tiered approach. This approach provides flexibility to a wide range of Parties with varying priorities and capacities.

5.1.2.1 Tiered approach methodology

The Tiered approach provides flexibility to a wide range of Parties with varying priorities and capacities. The Tiered approach consists of three steps namely, initial assessment (tier I), preliminary inventory (Tier II) and in-depth inventory (Tier III). The schematic presentation of the tiered approach is shown in Figure 5-1.

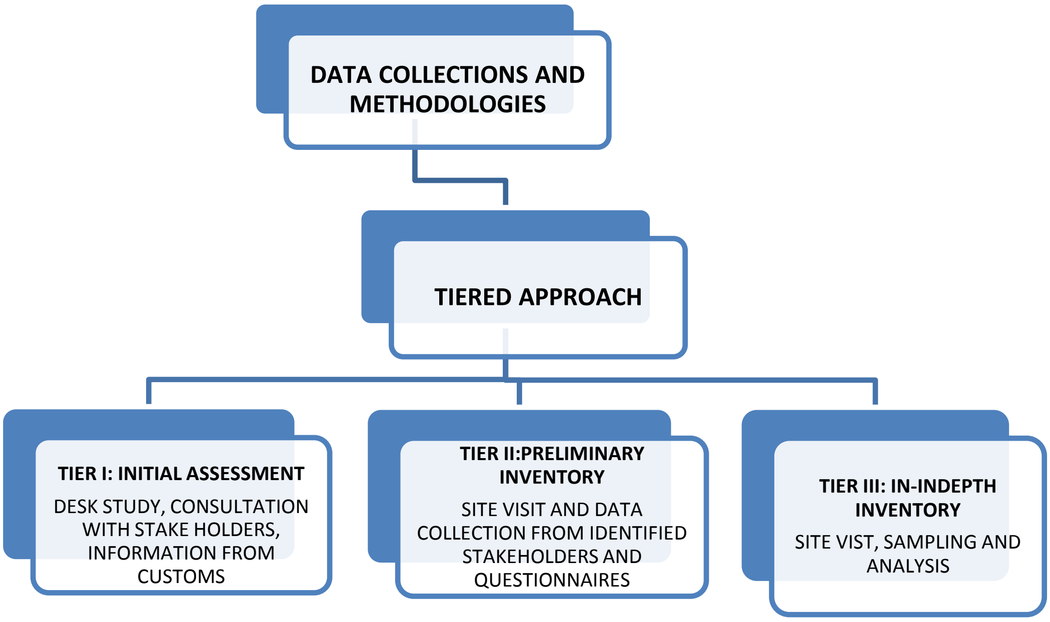

Figure 5-1: Tiered approach methodology for data collection

Tier I: Initial assessment

The present report is centred on information collected using the Tier I, Tier II and in some cases Tier III approaches. Tier I generally relies on desk studies, interviews etc., i.e., methods that do not require expensive on-site visits or elaborates data collection activities. Tier II involves site visits and data collection from identified stakeholders and making use of questionnaires during site visits. Tier III involves sample collection from suspected contaminated sites and quantitatively analysed for POPs of interest. In the initial approach an overview of the former use of POPs in articles and waste/recycling flows are obtained:

- Production of POPs;
- Use of POPs;
- POPs in waste and recycling flow; and
- Life cycle of POPs and potential for emissions

Also information was collected on existing, past and present national data on the import and use of POPs and articles containing POPs from major stakeholders such as the following:

- Various government departments (the dti, DoH, DoT and others);
- SARS, Customs and Excise;
- Statistics SA;
- Published literature in scientific journals;

- Technical reports or notes, commissioned research reports and development assistance study reports;
- Desk study and online research; and
- Responses to the inquiries and interviews.

Tier II: Preliminary inventory

The preliminary inventory generally focuses on specific sectors. It involved surveys and site visits to better estimate national data that were identified as missing in the initial assessment/Tier I. Possible applications and target locations can be identified, followed by site visits including:

- Former production of POPs;
- E-waste collection centres and recyclers;
- Possible site visits of e-waste management facilities;
- Possible site visits of end-of-life vehicles treatment facilities;
- Possible site visits of storage and disposal locations materials containing POP-PBDEs.

Tier III: In-depth inventory

The in-depth inventory may be undertaken if the preliminary inventory concludes that POPs could pose high human health and environmental risks in the country and more accurate data are needed to prioritize risk reduction measures and estimate their costs. Data collection in this tier relies on the use of analytical methods that may include screening using X-ray fluorescence (XRF) and measurements using gas chromatography and electron capture detector (ECD) or mass spectrometry (GC-MS). It may also involve detailed inspections of sites.

It is worth mentioning that Tier III was not part of the current inventory. However, for the identification of contaminated sites, environmental samples were collected and analysed using GC-MS at the Environmental and Analytical Research laboratory at Tshwane University of Technology.

5.1.3 Collecting and compiling data from key sectors

The inventory needs to investigate if the following exists in the country:

- Production of POP chemicals;
- Industries currently or formerly using POPs-chemicals;

- Products and articles containing POPs-chemicals;
- POPs-chemicals in waste and how they are managed;
- Articles containing POPs-chemicals that are recycled, the possible extent of recycling, and the types of articles produced from recycling;
- Stockpiles and wastes from former production and use in industries;
- Sites/locations where activities have occurred that could be potentially contaminated with POPs-chemicals.

The following types of numerical data need to be collected and compiled in the inventory:

- Quantities of POPs-chemicals in waste and stockpiles and
- Quantities of POPs-chemicals present in articles and products.

Some of the focal sectors to be investigated in the national inventory of the listed POPs-chemicals fall under the following key areas:

- Electric and electronic equipment;
- Transport sector;
- Agriculture and stock industry;
- Health application;
- Other uses; and
- Identification of potential contaminated sites and hot spots.

5.1.4 Managing and evaluating the data

The management of collected data should be done as consistently and as transparently as possible. During the data processing, all the assumptions and conversion coefficients adopted as a result of expert judgment, where needed, should be noted or recorded and mentioned when the results are presented. Estimations will be needed to provide the total quantities in a country. Estimations are a valuable tool for providing the data needed when resources are limited. Since direct measurements of POPs-chemicals in products and articles are resource intensive, a preliminary inventory could be fully based on estimations in many. Some challenges may still exist at the end of the inventory including a lack of information. An evaluation of the process, strategy used and information collected can take place along with a decision on what further actions are needed to make the inventory more complete.
The evaluation includes identification of the following:

- Gaps and limitations;

- ➢ Need for validation of the information compiled in the inventory;
- ➢ Further actions needed to make the inventory more complete; and
- ➢ Further actions needed to meet the requirements of the Stockholm Convention.

5.1.5 Preparing the inventory report

The final step for the inventory is to prepare the POPs-chemical inventory report. This report will include the inventories of all key sectors investigated, compiled in a single document. Although its aim is to support the development of the NIP, the report can be also used for other purposes such as feeding into developing post NIP projects, and developing effective strategies and action plans for managing listed POPs-chemicals to meet the obligations under the Convention.

The essential elements of the report are:

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

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

In this report, tiers I and II were used to obtain the required information. However, tier III, although not part of the current study was used to quantify the concentrations of PBDEs in samples collected from landfill sites.

5.2 Conclusions

- ➢ Tiers I and II are adequate for the inventory of POP chemicals;
- ➢ Tier III was only applied to confirm the presence of POP-PBDE in contaminated sites;

CHAPTER 6 INVENTORY OF POP-PBDES IN ELECTRICAL AND ELECTRONIC EQUIPMENT (EEE), WASTE ELECTRICAL AND ELECTRONIC EQUIPMENT (WEEE), CONTAMINATED SITES QUANTITIES IMPORTED INTO SOUTH AFRICA AS CHEMICALS

6.1 Introduction

The development of a national inventory of products and articles containing the ten new POPs chemicals requires cooperation with the relevant authority in charge of manufacturers of consumer products, suppliers, retailers and the customs service, as well as other relevant authorities and organizations. The current chapter describes the results obtained on the quantities of POP-PBDEs in electronic and electrical equipment (EEE), waste electrical and electronic equipment (WEEE) (cathode ray tubes for television and personal computers, information communication technology equipment and refrigerators) and the levels of POP-PBDEs n landfill sites were collected, calculated and tabulated.

6.2 Methodology

The Tier 1 (initial assessment) approach was used to collate the information presented in the current report. Telephone calls and emails were used to contact the following stakeholders to provide information on the ten new POPs. Equations as contained in the UNEP Toolkit for POP chemical inventory were used to calculate the quantities of POP-PBDE in electrical and electronic equipment. The harmonized codes for industrial chemicals and PBDEs imported into South Africa were used to identify imported and exported PBDEs. The imput data used in the computations to generate the quantities of POP-PBDEs was obtained from various sources such as Statics South Africa, UNCOMTRADE, the Department of Trade and Industry of South Africa (**the dti**), South African Revenue Services (SARS), private companies and other government departments. The equations as contained in the UNEP toolkit for the EEE and WEEE toolkit for POP-PBDEs were used in this study.

Sediment and leachate samples (summer and winter) were collected from landfill sites in Pretoria and Johannesburg (Chloorkop, Garskloof, Hatherly, Onderstepoort, Robinson deep and Soshanguve) and analysed for PBDEs in order to ascertain whether these sites can be regarded as contaminated. The selection of the landfill sites was based predominantly on the generation of leachate and accessibility. About 10 g of dried and sieved (250 µm) sediment samples were extracted in a Soxhlet apparatus using 170 mL (dichloromethane: hexane 1:1,*v/v*) for 10 h. In the case of leachate samples, about 500 mL of leachate samples was extracted thrice using liquid-liquid (LLE). Dichloromethane and dichloromethane/hexane were used for LLE. Extracts were reduced to 1mL before subjecting to column cleaning. The cleaned extracts were concentrated to 1 mL under a gentle stream of nitrogen and solvent exchanged to hexane before injecting 1µL into the GC-MS for analysis. Triplicate extract of the sediment was carried out. ZB-5 capillary column 15 m, 0.25 mm i.d., 0.25 µm d_f and 15 m, 0.25 mm i.d., 0.1 µm d_f was used for separation and helium used as the carrier gas.

6.3 Determination of quantities of POP PBDEs in electrical and electronic equipment in stock, waste stream, polymer fraction (from recycling) and transport in South Africa

6.3.1. POP-PBDEs in Stock

The information on stock of EEE in South Africa was obtained from Statistics SA. With respect to televisions the number of households and the weight of each television (TV) and the percentage of households owning TV, the total weight of TV in tonnes was then calculated using the equation below:

$$\textbf{Total weight} = [\textbf{Weight of EEE}] \times [\textbf{No. of Households}] \times [f_{\textbf{households with EEE}}]$$

$$M_{PBDE\ (i)} = [\textbf{Total weight (tonnes)}] \times [f_{polymer}] \times [C_{c\text{-}OctaBDE;Polymer}]$$

where:
$M_{PBDE(i)}$ – is the amount of POP-PBDEs (i) in [kg]
$F_{Polymer}$ – is the total polymer fraction in EEE (0.15 – 0.38) (Waeger et al., 2008)
$C_{c\text{-}OctaPBDE;Polymer}$ – is the content of the c-OctaPBDE in the polymer fraction of EEE [kg/metric tonnes]
For CRT TVs the $C_{c\text{-}OctaPBDE;Polymer}$ = 0.00087 kg/metric tonnes

6.3.1.1 c-OctaBDE in electrical and electronic equipment TV Stock

The preceeding equation was also used for other EEE stock, except the variation in the polymer fraction for individual EEE. The POP-PBDE was determined in electronic and electrical equipment (TV, PC-Computer, monitors, ICT equipment without monitors (cellphones, radios and telephones) and consumer equipment without monitors (electric stoves, vacuum cleaners, washing machines and refrigerators) in stock in South Africa in 2001, 2007 and 2011. Emphasis is on c-OctaBDE since this was used specifically in electronics and electrical equipment. Tables 6-1-6-10 show the POP-PBDEs and Σc-OctaBDE in stock EEE. The Σc-OctaBDE for hexaBDE present in televisions are 4.4810 kg, 5.877 and 7.779 for 2001, 2007 and 2011 respectively. There is a general increase from

2001-2011, probably due increase in use. The Σc-OctaBDE for heptaBDE calculated range from 17.515 kg (2001), 22.973 kg (2007) and 30.408kg (2011). With respect to Σc-OctaBDE for octaBDE the values range from 14.257 kg, 18.699 kg and 25.750 kg for 2001, 2007 and 2011 respectively.

Table 6-1: POP-PBDE present in TV stock

TV								
Year	**Total weight [10^3 tonnes]**	**Total number [million units]**	**Population [million capita]**	**CRT weight/person [kg/capita]**	**Number of CRTs/person [units/capita]**	**Minimum POP-PBDE (i) [kg]**	**Maximum POP-PBDE (i) [kg]**	**Mean POP-PBDE (i) [kg]**
	A	**B (A/25)**	**C**	**D (A/C)**	**(B/C)**	**$F_{Polymer}$ = 15%**	**$F_{Polymer}$ = 38%**	**$F_{Polymer}$ = 30%**
2001	*156065.0*	*6242.6*	*45*	*3.47*	*138.724*	*20.366*	*51.595*	*40.733*
2007	*204697.5*	*8187.9*	*49*	*4.18*	*167.100*	*26.713*	*67.673*	*53.426*
2011	*270940.5*	*10837.6*	*52*	*5.21*	*208.416*	*35.358*	*89.573*	*70.715*

Table 6-2: c-OctaBDE composites present in TV stock (mainly HexaBDE, HeptaBDE & octaBDE)

Inventory c-OctaBDE		**POP-PBDEs in stock**		
Homologues	**Distribution homologues c-OctaBDE**	**∑c-OctaBDE**		
		2001	**2007**	**2011**
HexaBDE**	**11%**	***4.481***	***5.877***	***7.779***
HeptaBDE**	**43%**	***17.515***	***22.973***	***30.408***
OctaBDE**	**35%**	***14.257***	***18.699***	***24.750***
NonaBDE*	10%	*4.073*	*5.343*	*7.072*
DecaBDE*	1%	*0.407*	*0.534*	*0.707*
c-OctaBDE	**100%**	***40.733***	***53.426***	***70.715***

*NonaBDE and DecaBDE are not listed as POPs
**The percentage of the PBDE homologue that are POP-PBDEs

In the case of PC Computers (Tables 6-3-6-4), the Σc-OctaBDE for hexaBDE, range from 0.863 kg, 1.618 kg and 2.518 kg for 2001, 2007 and 2011 respectively. For heptaBDE the values range from 3.375 kg (2001), 6.326 kg (2007) and 9.844 kg (2011). For the octaBDE the following values were calculated: 2.747 kg (2001), 5.149 kg (2007) and 8.012 kg (2011).

The Σc-OctaBDE in monitors is distributed as follows: hexBDE 1.230 kg (2001), 0.2304 (2007) and 3.586 kg (2011). The values of heptaBDE range from 4.807 kg (2001), 0.9008 kg and 14.020 kg (2011) and octaBDE 3.913 kg (2001), 0.7332 kg (2007) and 11.411 kg (2011). \

Table 6-3: POP-PBDE present in PC computers stock

PC Computers								
Year	**Total weight [10^3 tonnes]**	**Total number [million units]**	**Population [million capita]**	**CRT weight/person [kg/capita]**	**Number of CRTs/person [units/capita]**	**Minimum POP-PBDE (i) [kg]**	**Maximum POP-PBDE (i) [kg]**	**Mean POP-PBDE (i) [kg]**
	A	**B (A/9.9)**	**C**	**D (A/C)**	**(B/C)**	**$F_{Polymer}$ = 13%**	**$F_{Polymer}$ = 38%**	**$F_{Polymer}$ = 30%**
2001	*10300.3*	*1040.4*	*45*	*0.229*	*23.121*	*3.401*	*9.942*	*7.849*
2007	*19305.9*	*1950.1*	*49*	*0.394*	*39.798*	*6.375*	*18.634*	*14.711*
2011	*30041.9*	*3034.5*	*52*	*0.578*	*58.356*	*9.920*	*28.996*	*22.892*

Total weight = [Weight of EEE] x [No. of Households] x [$f_{households\ with\ EEE}$]
CRT – Cathod Ray Tube
$M_{PBDE(i)}$ – is the amount of POP-PBDEs (i) in [kg]
$M_{PBDE(i)}$ = [Total weight (tonnes)] x [$f_{polymer}$] x [$C_{c\text{-}OctaBDE;Polymer}$] where:
Weight of CRTs/device estimate average is 9.9 kg for either TV or PC monitors (EMPA, 2011)
$F_{Polymer}$ – is the total polymer fraction in EEE (0.13 – 0.38) (Waeger et al., 2008)
$C_{c\text{-}OctaPBDE;Polymer}$ – is the content of the c-OctaPBDE in the polymer fraction of EEE [kg/metric tonnes]
For CRT monitors the $C_{c\text{-}OctaPBDE;Polymer}$ = 0.00254 kg/metric tonnes

Table 6-4: c-OctaBDE composites (mainly HexaBDE, HeptaBDE & octaBDE) present in PC computer stock

Inventory c-OctaBDE		POP-PBDEs in stock		
Homologues	**Distribution homologues c-OctaBDE**	**∑c-OctaBDE**		
		2001	**2007**	**2011**
HexaBDE**	**11%**	***0.863***	***1.618***	***2.518***
HeptaBDE**	**43%**	***3.375***	***6.326***	***9.844***
OctaBDE**	**35%**	***2.747***	***5.149***	***8.012***
NonaBDE*	10%	*0.785*	*1.471*	*2.289*
DecaBDE*	1%	*0.078*	*0.147*	*0.229*
c-OctaBDE	**100%**	***7.849***	***14.711***	***22.892***

*NonaBDE and DecaBDE are not listed as POPs
**The percentage of the PBDE homologue that are POP-PBDEs

In the case of ICT equipment without monitors (cellphones, radios and telephones) the values calculated for hexaBDE are as follows (Table 6.6): 2.192 kg (2001), 2.229 kg (2007) and 2.717 kg (2011). For 2001, 2007 and 2011, the values for heptaBDE are 8.569 kg, 8.712 kg and 10.621 kg respectively. For octaBDE the values range from 6.974 kg (2001), 7.091 kg (2007) and 8.645 kg (2011).

Table 6-5: POP-PBDE present in ICT equipment without monitor stock

ICT equipment without monitors (cellphones, radio, telephones)								
Year	**Total weight [10^3 tonnes]**	**Total number [million units]**	**Population [million capita]**	**CRT weight/person [kg/capita]**	**Number of CRTs/person [units/capita]**	**Minimum POP-PBDE (i) [kg]**	**Maximum POP-PBDE (i) [kg]**	**Mean POP-PBDE (i) [kg]**
	A	**B (A/3.1#)**	**C**	**D (A/C)**	**(B/C)**	**$F_{Polymer}$ = 26%**	**$F_{Polymer}$ = 58%**	**$F_{Polymer}$ = 42%**
2001	*21086.9*	*6802.2*	*45*	*0.469*	*151.160*	*12.336*	*27.518*	*19.927*
2007	*21438.6*	*6915.7*	*49*	*0.438*	*141.136*	*12.542*	*27.977*	*20.259*
2011	*26138.3*	*8431.7*	*52*	*0.503*	*162.148*	*15.291*	*34.111*	*24.701*

#The sum weight of ICT equipment without monitor was used (cellphones = 0.1 kg, radio = 2 kg, telephones =1 kg)
Total weight = [Weight of EEE] x [No. of Households] x [$f_{households\ with\ EEE}$]
CRT – Cathod Ray Tube
$M_{PBDE(i)}$ – is the amount of POP-PBDEs (i) in [kg]
$M_{PBDE(i)}$ = [Total weight (tonnes)] x [$f_{polymer}$] x [$C_{c\text{-}OctaBDE;Polymer}$] where:
Sum weight of ICT equipment without monitor is 3.1 kg (Huisman et al., 2008; Laffely, 2007; EMPA, 2011)
$F_{Polymer}$ – is the total polymer fraction in EEE (0.26 – 0.58) (Waeger et al., 2008)
$C_{c\text{-}OctaPBDE;Polymer}$ – is the content of the c-OctaPBDE in the polymer fraction of EEE [kg/metric tonnes]
For ICT equipment without monitor $C_{c\text{-}OctaPBDE;Polymer}$ = 0.00225 kg/metric tonnes

Table 6-6: c-OctaBDE present in ICT equipment without monitor stock (mainly HexaBDE, HeptaBDE & octaBDE)

Inventory c-OctaBDE		**POP-PBDEs in stock**		
Homologues	**Distribution homologues c-OctaBDE**	**∑c-OctaBDE**		
		2001	**2007**	**2011**
HexaBDE**	**11%**	***2.192***	***2.229***	***2.717***
HeptaBDE**	**43%**	***8.569***	***8.712***	***10.621***
OctaBDE**	**35%**	***6.974***	***7.091***	***8.645***
NonaBDE*	10%	*1.993*	*2.026*	*2.470*
DecaBDE*	1%	*0.199*	*0.203*	*0.247*
c-OctaBDE	**100%**	***19.927***	***20.259***	***24.701***

*NonaBDE and DecaBDE are not listed as POPs
**The percentage of the PBDE homologue that are POP-PBDEs

Tables 6.7-6.8 show the quantities of POP-PBDE in ICT equipment with monitor. As can be seen in Table 6.8, the ∑c-OctaBDE ranged from 0.2304-14.020.The highest quantity was recorded for stock in 2011; while the lowest was observed in 2007.

Table 6-7: POP-PBDE present in ICT with monitor stock

Monitor								
Year	**Total weight [10^3 tonnes]**	**Total number [million units]**	**Population [million capita]**	**CRT weight/person [kg/capita]**	**Number of CRTs/person [units/capita]**	**Minimum POP-PBDE (i) [kg]**	**Maximum POP-PBDE (i) [kg]**	**Mean POP-PBDE (i) [kg]**
	A	**B (A/14.1)**	**C**	**D (A/C)**	**(B/C)**	**$F_{Polymer}$ = 13%**	**$F_{Polymer}$ = 38%**	**$F_{Polymer}$ = 30%**
2001	*14670.1*	*1040.433*	*45*	*0.326*	*23.121*	*4.844*	*14.160*	*11.179*
2007	*2749.3*	*194.989*	*49*	*0.056*	*3.979*	*0.908*	*2.654*	*2.095*
2011	*42786.9*	*3034.534*	*52*	*0.823*	*58.356*	*14.128*	*41.298*	*32.604*

Total weight = [Weight of EEE] x [No. of Households] x [$f_{households\ with\ EEE}$]
CRT – Cathod Ray Tube
$M_{PBDE(i)}$ – is the amount of POP-PBDEs (i) in [kg]
$M_{PBDE(i)}$ = [Total weight (tonnes)] x [$f_{polymer}$] x [$C_{c\text{-}OctaBDE;Polymer}$] where:
Weight of CRTs/device estimate average is 14.1 kg for either TV or PC monitors (EMPA, 2011)
$F_{Polymer}$ – is the total polymer fraction in EEE (0.13 – 0.38) (Waeger et al., 2008)
$C_{c\text{-}OctaPBDE;Polymer}$ – is the content of the c-OctaPBDE in the polymer fraction of EEE [kg/metric tonnes]
For CRT monitors the $C_{c\text{-}OctaPBDE;Polymer}$ = 0.00254 kg/metric tonnes

Table 6-8: c-OctaBDE composites present in ICT with monitor stock (mainly HexaBDE, HeptaBDE & octaBDE)

Inventory c-OctaBDE		**POP-PBDEs in stock**		
Homologues	**Distribution homologues c-OctaBDE**	**∑c-OctaBDE**		
		2001	**2007**	**2011**
HexaBDE**	**11%**	***1.230***	***0.2304***	***3.586***
HeptaBDE**	**43%**	***4.807***	***0.9008***	***14.020***
OctaBDE**	**35%**	***3.913***	***0.7332***	***11.411***
NonaBDE*	10%	*1.118*	*0.2095*	*3.260*
DecaBDE*	1%	*0.112*	*0.0209*	*0.326*
c-OctaBDE	**100%**	***11.179***	***2.0950***	***32.604***

*NonaBDE and DecaBDE are not listed as POPs
**The percentage of the PBDE homologue that are POP-PBDEs

For the consumer equipment without monitor (electric stove, vacuum cleaner, washing machine and refrigerator) the values for hexBDE calculated are: 59.24 kg (2001), 8.03 kg (2007) 341.31 kg (2011) (Table 6-10). The values calculated for heptaBDE range from

231.59 kg (2001), 31.38 kg (2007) and 1034.21 (2011). The following values were obtained for c-OctaBDE: 188.50 kg (2001), 25.54 kg (2007) and 1085.98 kg (2011).

Table 6-9: POP-PBDE present in consumer equipment without monitor stock

Consumer equipment without monitor (electric stove, vacuum cleaner, washing machine, refrigerator)								
Year	**Total weight [10^3 tonnes]**	**Total number [million units]**	**Population [million capita]**	**CRT weight/person [kg/capita]**	**Number of CRTs/person [units/capita]**	**Minimum POP-PBDE (i) [kg]**	**Maximum POP-PBDE (i) [kg]**	**Mean POP-PBDE (i) [kg]**
	A	**B (A/35*) (A/154#)**	**C**	**D (A/C)**	**(B/C)**	**$F_{Polymer}$ = 13%**	**$F_{Polymer}$ = 38%**	**$F_{Polymer}$ = 30%**
2001*	*206352.6*	*5895.8*	*45*	*4.586*	*131.018*	*233.385*	*682.202*	*538.580*
2007*	*27956.1*	*798.7*	*49*	*0.571*	*16.301*	*31.618*	*92.423*	*72.965*
2011#	*1188814.7*	*7476.8*	*52*	*22.862*	*143.785*	*1344.549*	*3930.222*	*3102.806*

*Data for refrigerator only = 35 kg
#The sum weight of ICT EEE was used (electric stove = 46 kg, vacuum cleaner = 8 kg, washing machine = 65 kg, refrigerator = 35 kg)
Total weight = [Weight of EEE] x [No. of Households] x [$f_{households\ with\ EEE}$]
CRT – Cathod Ray Tube
$M_{PBDE(i)}$ – is the amount of POP-PBDEs (i) in [kg]
$M_{PBDE(i)}$ = [Total weight (tonnes)] x [$f_{polymer}$] x [$C_{c\text{-}OctaBDE;Polymer}$] where:
*Sum weight of consumer equipment without monitor 35 kg
#Sum weights of consumer equipment without monitor 154 kg (Huisman et al., 2008; Laffely, 2007; EMPA, 2011)
$F_{Polymer}$ – is the total polymer fraction in EEE (0.13 – 0.38) (Waeger et al., 2008)
$C_{c\text{-}OctaPBDE;Polymer}$ – is the content of the c-OctaPBDE in the polymer fraction of EEE [kg/metric tonnes]
For Consumer equipment without monitor the $C_{c\text{-}OctaPBDE;Polymer}$ = 0.00015 kg/metric tones

Table 6-10: c-OctaBDE composites present in consumer equipment without monitor in stock (mainly HexaBDE, HeptaBDE & octaBDE)

Inventory c-OctaBDE		**POP-PBDEs in stock**		
Homologues	**Distribution homologues c-OctaBDE**	**∑c-OctaBDE**		
		2001	**2007**	**2011**
HexaBDE**	11%	***59.24***	***8.03***	***341.31***
HeptaBDE**	43%	***231.59***	***31.38***	***1334.21***
OctaBDE**	35%	***188.50***	***25.54***	***1085.98***
NonaBDE*	10%	*53.86*	*7.30*	*310.28*
DecaBDE*	1%	*5.39*	*0.73*	*31.03*
c-OctaBDE	**100%**	***538.58***	***72.97***	***3102.81***

*NonaBDE and DecaBDE are not listed as POPs
**The percentage of the PBDE homologue that are POP-PBDEs

6.3.2 POP-PBDEs in stock entering the waste stream

The aforementioned equations under stock were also used for determining the quantities of POP chemicals in stock entering the waste stream. However, the life of each EEE was factored into the equation given below:

WEEE generated per year = M_{EEE}(*j*)stockpiled / ls_{EEE}(*j*)
Where
- M_{EEE}(j)stockpiled is the amount of EEE (*j*) stockpiled at the consumer [in metric tons]
- ls_{EEE}(*j*) is the average life span of the specific appliance (*j*) [in years] (combined time of being used and stored at the consumer)

6.3.2.1 WEEE TV stock entering the waste stream

The results for WEEE stock entering the waste stream were determined and are shown in Tables 6-11-6-20. The Σc-OctaBDE for hexaBDE present in televisions was, 0.44810 kg, 0.5877 and 0.7779 for 2001, 2007 and 2011 respectively. There is a general increase from 2001-2011, probably due increase in use. The Σc-OctaBDE for heptaBDE calculated range from 1.7515 kg (2001), 2.2973 kg (2007) and 3.0408kg (2011). With respect to Σc-OctaBDE for octaBDE the values range from 1.426 kg, 1.860 kg and 2.575 kg for 2001, 2007 and 2011 respectively.

Table 6-11: POP-PBDE present in TV entering the waste stream

TV								
Year	**Total weight [10 3 tonnes]**	**Total number [million units]**	**Population [million capita]**	**CRT weight/person [kg/capita]**	**Number of CRTs/person [units/capita]**	**Minimum POP-PBDE (i) [kg]**	**Maximum POP-PBDE (i) [kg]**	**Mean POP-PBDE (i) [kg]**
	A	**B (A/25)**	**C**	**D (A/C)**	**(B/C)**	**$F_{Polymer}$ = 15%**	**$F_{Polymer}$ = 38%**	**$F_{Polymer}$ = 30%**
2001	*15606.5*	*624.3*	*45*	*0.35*	*13.872*	*2.037*	*5.160*	*4.073*
2007	*20469.7*	*818.8*	*49*	*0.42*	*16.710*	*2.671*	*6.767*	*5.343*
2011	*27094.1*	*1083.8*	*52*	*0.52*	*20.842*	*3.536*	*8.957*	*7.072*

IsEEE = 10

Table 6-12: c-OctaBDE composites present in TV entering the waste stream (mainly HexaBDE, HeptaBDE & octaBDE)

Inventory c-OctaBDE		POP-PBDEs entering into the waste stream		
Homologues	**Distribution homologues c-OctaBDE**	**∑c-OctaBDE**		
		2001	**2007**	**2011**
HexaBDE**	**11%**	***0.448***	***0.588***	***0.778***
HeptaBDE**	**43%**	***1.752***	***2.297***	***3.041***
OctaBDE**	**35%**	***1.426***	***1.870***	***2.475***
NonaBDE*	10%	*0.407*	*0.534*	*0.707*
DecaBDE*	1%	*0.041*	*0.053*	*0.071*
c-OctaBDE	**100%**	***4.073***	***5.343***	***7.072***

*NonaBDE and DecaBDE are not listed as POPs
**The percentage of the PBDE homologue that are POP-PBDEs

6.3.2.2 WEEE PC stock entering the waste stream

In the case of PC Computers (Table 6-13-6-14), the Σc-OctaBDE for hexaBDE, range from 0.216 kg, 0.405 kg and 0.630 kg for 2001, 2007 and 2011 respectively. For heptaBDE the values range from 0.844 kg (2001), 1.591 kg (2007) and 2.461 kg (2011). For the octaBDE the following values were calculated: 0.687 kg (2001), 1.2879 kg (2007) and 2.003 kg (2011). The Σc-OctaBDE in monitors is distributed as follows: hexBDE 0.286 kg (2001), 0.0536 (2007) and 0.834 kg (2011). The values of heptaBDE range from 1.118 kg (2001), 0.2095 kg and 3.260 kg (2011) and octaBDE 0.910 kg (2001), 0.1705 kg (2007) and 2.654 kg (2011).

Table 6-13: POP-PBDE present in PC computers entering the waste stream

PC Computers								
Year	**Total weight [10 3 tonnes]**	**Total number [million units]**	**Population [million capita]**	**CRT weight/person [kg/capita]**	**Number of CRTs/person [units/capita]**	**Minimum POP-PBDE (i) [kg]**	**Maximum POP-PBDE (i) [kg]**	**Mean POP-PBDE (i) [kg]**
	A	**B (A/9.9)**	**C**	**D (A/C)**	**(B/C)**	**$F_{Polymer}$ = 13%**	**$F_{Polymer}$ = 38%**	**$F_{Polymer}$ = 30%**
2001	*2575.1*	*260.1*	*45*	*0.057*	*5.780*	*0.850*	*2.485*	*1.962*
2007	*4826.5*	*487.5*	*49*	*0.098*	*9.949*	*1.594*	*4.659*	*3.678*
2011	*7510.5*	*758.6*	*52*	*0.144*	*14.589*	*2.480*	*7.249*	*5.723*

IsEEE = 4

Table 6-14: c-OctaBDE composites present in PC computer entering the waste stream (mainly HexaBDE, HeptaBDE & octaBDE)

Inventory c-OctaBDE		POP-PBDEs entering into the waste stream		
Homologues	**Distribution homologues c-OctaBDE**	**∑c-OctaBDE**		
		2001	**2007**	**2011**
HexaBDE**	**11%**	***0.216***	***0.405***	***0.630***
HeptaBDE**	**43%**	***0.844***	***1.581***	***2.461***
OctaBDE*	**35%**	***0.687***	***1.287***	***2.003***
NonaBDE*	10%	*0.196*	*0.368*	*0.572*
DecaBDE*	1%	*0.020*	*0.037*	*0.057*
c-OctaBDE	**100%**	***1.962***	***3.678***	***5.723***

*OctaBDE, NonaBDE and DecaBDE are not listed as POPs
**The percentage of the PBDE homologue that are POP-PBDEs

6.3.2.3 WEEE ICT without monitor stock entering the waste stream

In the case of ICT equipment without monitors (cellphones, radios and telephones) the values calculated for hexaBDE are as follows: 0.664 kg (2001), 0.675 kg (2007) and 0.823 kg (2011) (Tables 6-15-16). For 2001, 2007 and 2011, the values for heptaBDE are 2.597 kg, 2.640 kg and 13.219 kg respectively. For octaBDE the values range from 2.113 kg (2001), 2.109 kg (2007) and 2.620 kg (2011).

Table 6-15: POP-PBDE present in ICT equipment without monitor entering the waste stream

ICT equipment without monitors (cellphones, radio, telephones)								
Year	**Total weight [10 3 tonnes]**	**Total number [million units]**	**Population [million capita]**	**CRT weight/person [kg/capita]**	**Number of CRTs/person [units/capita]**	**Minimum POP-PBDE (i) [kg]**	**Maximum POP-PBDE (i) [kg]**	**Mean POP-PBDE (i) [kg]**
	A	**B (A/3.1)**	**C**	**D (A/C)**	**(B/C)**	**$F_{Polymer}$ = 26%**	**$F_{Polymer}$ = 58%**	**$F_{Polymer}$ = 42%**
2001	*6390.0*	*2061.3*	*45*	*0.142*	*45.806*	*3.738*	*8.339*	*6.039*
2007	*6496.5*	*2095.7*	*49*	*0.133*	*42.769*	*3.800*	*8.478*	*6.139*
2011	*7920.7*	*2555.1*	*52*	*0.152*	*49.136*	*4.634*	*10.337*	*7.485*

The sum weight of ICT EEE was used (cellphones = 0.1 kg, radio = 2 kg, telephones = 1 kg)
IsEEE = 3.3* (average IsEEE of printer + cellphones)

Table 6-16: c-OctaBDE composites present in ICT equipment without monitor entering the waste stream (mainly HexaBDE, HeptaBDE & octaBDE)

Inventory c-OctaBDE		POP-PBDEs entering into the waste stream		
Homologues	Distribution homologues c-OctaBDE	∑c-OctaBDE		
		2001	2007	2011
HexaBDE**	**11%**	***0.664***	***0.675***	***0.823***
HeptaBDE**	**43%**	***2.597***	***2.640***	***3.219***
OctaBDE**	**35%**	***2.113***	***2.149***	***2.620***
NonaBDE*	10%	*0.604*	*0.614*	*0.749*
DecaBDE*	1%	*0.060*	*0.061*	*0.075*
c-OctaBDE	**100%**	***6.039***	***6.139***	***7.485***

*NonaBDE and DecaBDE are not listed as POPs
**The percentage of the PBDE homologue that are POP-PBDEs

6.3.2.4 WEEE ICT with monitor stock entering the waste stream

Tables 6-17-6-18 show the quantites of POP-PBDE present in ICT with monitor entering the waste stream.As can be seen in Table 6-18, the ∑c-OctaBDE ranged from 0.2095-3.260.Again the highest quantity was observed in 2011 and the lowest in 2007.

Table 6-17: c-OctaBDE composites (mainly HexaBDE, HeptaBDE & octaBDE) present in monitor entering the waste stream

Monitor								
Year	**Total weight [10 3 tonnes]**	**Total number [million units]**	**Population [million capita]**	**CRT weight/person [kg/capita]**	**Number of CRTs/person [units/capita]**	**Minimum POP-PBDE (i) [kg]**	**Maximum POP-PBDE (i) [kg]**	**Mean POP-PBDE (i) [kg]**
	A	**B (A/14.1)**	**C**	**D (A/C)**	**(B/C)**	$F_{Polymer}$ **= 13%**	$F_{Polymer}$ **= 38%**	$F_{Polymer}$ **= 30%**
2001	*3411.7*	*241.961*	*45*	*0.076*	*5.377*	*1.127*	*3.293*	*2.600*
2007	*639.4*	*45.346*	*49*	*0.013*	*0.925*	*0.211*	*0.617*	*0.487*
2011	*9950.4*	*705.706*	*52*	*0.191*	*13.571*	*3.286*	*9.604*	*7.582*

Table 6-18: c-OctaBDE composites present in monitor entering the waste stream (mainly HexaBDE, HeptaBDE & octaBDE)

Inventory c-OctaBDE		POP-PBDEs entering into the waste stream		
Homologues	**Distribution homologues c-OctaBDE**	**∑c-OctaBDE**		
		2001	**2007**	**2011**
HexaBDE**	**11%**	***0.286***	***0.0536***	***0.834***
HeptaBDE**	**43%**	***1.118***	***0.2095***	***3.260***
OctaBDE**	**35%**	***0.910***	***0.1705***	***2.654***
NonaBDE*	10%	*0.260*	*0.0487*	*0.758*
DecaBDE*	1%	*0.026*	*0.0049*	*0.076*
c-OctaBDE	**100%**	***2.600***	***0.4872***	***7.582***

*NonaBDE and DecaBDE are not listed as POPs
**The percentage of the PBDE homologue that are POP-PBDEs

6.3.2.5 WEEE consumer equipment without monitor stock entering the waste stream

For the consumer equipment without monitor (electric stove, vacuum cleaner, washing machine and refrigerator) the values for hexBDE calculated are: 7.14 kg (2001), 0.97 kg (2007) 41.12 kg (2011). The values calculated for heptaBDE range from 27.90 kg (2001), 3.78 kg (2007) and 160.75 (2011)(Tables 6-19-6-20). The following values were obtained for c-OctaBDE: 22.71 kg (2001), 3.08 kg (2007) and 130.84 kg (2011).

Table 6-19: POP-PBDE present in consumer equipment without monitor entering the waste stream

Consumer equipment without monitor (electric stove, vacuum cleaner, washing machine, refrigerator)								
Year	**Total weight [10 3 tonnes]**	**Total number [million units]**	**Population [million capita]**	**CRT weight/person [kg/capita]**	**Number of CRTs/person [units/capita]**	**Minimum POP-PBDE (i) [kg]**	**Maximum POP-PBDE (i) [kg]**	**Mean POP-PBDE (i) [kg]**
	A	**B (A/35*)**	**C**	**D (A/C)**	**(B/C)**	**$F_{Polymer}$ = 13%**	**$F_{Polymer}$ = 38%**	**$F_{Polymer}$ = 30%**
2001*	*24861.8*	*710.3*	*45*	*0.552*	*15.785*	*28.119*	*82.193*	*64.889*
2007*	*3368.2*	*96.2*	*49*	*0.069*	*1.964*	*3.809*	*11.135*	*8.791*
2011#	*143230.7*	*900.8*	*52*	*2.754*	*17.323*	*161.994*	*473.521*	*373.832*

*Data for refrigerator only = 35 kg
#The sum weight of ICT EEE was used (electric stove = 46 kg, vacuum cleaner = 8 kg, washing machine = 65 kg, refrigerator = 35 kg)
IsEEE = 8.3* (average IsEEE of refrigerator + washing machine + microwave)

Table 6-20: c-OctaBDE composites present in consumer equipment without monitor entering the waste stream (mainly HexaBDE, HeptaBDE & octaBDE)

Inventory c-OctaBDE		**POP-PBDEs entering into the waste stream**		
Homologues	**Distribution homologues c-OctaBDE**	**∑c-OctaBDE**		
		2001	**2007**	**2011**
HexaBDE**	**11%**	***7.14***	***0.97***	***41.12***
HeptaBDE**	**43%**	***27.90***	***3.78***	***160.75***
OctaBDE**	**35%**	***22.71***	***3.08***	***130.84***
NonaBDE*	10%	*6.49*	*0.88*	*37.38*
DecaBDE*	1%	*0.65*	*0.09*	*3.74*
c-OctaBDE	**100%**	***64.89***	***8.79***	***373.83***

*NonaBDE and DecaBDE are not listed as POPs
**The percentage of the PBDE homologue that are POP-PBDEs
The sum weight of ICT EEE was used (cellphones = 0.1 kg, radio = 2 kg, telephones = 1 kg)
IsEEE = 3.3* (average IsEEE of printer + cellphones)

6.3.3 Recycling (polymer fraction)

The following fractions as described in the UNEP Toolkit were used to determine the quantities of polymer fractions in recycled EEE products: 0.225 for ICT without monitors; 2.25 for CRT monitors; 0.15 for consumer equipment without monitors and 0.87 for TV CRT monitors. The results of polymer fraction in mixed recycled WEEE are shown in Table 6-21. The mean values for polymer fractions in ICT equipment without monitors range from 45.675 -95.85 kg/ton; CRT monitors 492.75-958.5 kg/ton; consumer equipment without monitors 30.45-63.9 kg/ton; TV CRT monitors 176.61-370.62 kg/ton for 2007-2011.

Table 6-21: POP-PBDE in polymer fraction (2007-2011)

Name of WEEE Product		Quantity Received (in Tons)				
		Year				
		2007	2008	2009	2010	2011
1. PC's		49	13	4	186	15
2. Printers		56	53	49	131	10
3. Cell's		5	3	6	2	*
4.TV's		15	*	2	1.3	0.8
5. Hi Fi's		8	*	*	*	*
6. Fridges		*	*	*	*	*
7. Photocopiers		70	2	*	*	*
8. Fax Machines		*	*	*	0.1	*
9. Others (E-waste)		1531	2774	3121	5080	4526
10. POLYMER		203	277	332	219	426
c-OctaBDE content in total polymer fractions in [kg/ metric tonne] * (COctaBDE;Polymer)						
ICT equipment without monitors	Min (0.05)	10.15	13.85	16.6	10.95	21.3
	Max (0.4)	81.2	110.8	132.8	87.6	170.4
	Mean (0.225)	45.675	62.325	74.7	49.275	95.85
CRT monitors	Min (0.14)	28.42	38.78	46.48	30.66	59.64
	Max (10.6)	2151.8	2936.2	3519.2	2321.4	4515.6
	Mean (2.25)	456.75	623.25	747	492.75	958.5
Consumer equipment without monitors	Min	-	-	-	-	-
	Max	-	-	-	-	-
	Mean (0.15)	30.45	41.55	49.8	32.85	63.9
TV CRT monitors	Min (0.05)	10.15	13.85	16.6	10.95	21.3
	Max (3.54)	718.62	980.58	1175.28	775.26	1508.04
	Mean (0.87)	176.61	240.99	288.84	190.53	370.62

6.3.4 POP-PBDEs in transport

For the determination of POP chemicals in transport imported into South Africa from the USA and other regions, the following equation was used:

Total amount of POP PBDEs in cars in used manufactured in USA =No of cars and trucks x 0.16 x 0.5

For cars and trucks imported from other regions, the following equation was used

Total amount of POP PBDEs in cars in used manufactured in other region =No of cars and trucks x 0.16 x 0.05

Tables 6-22 and 6-23 show the POP-PBDE in imported vehicles from other regions and the USA respectively. The values calculated for the POP-PBDE in imported cars into South Africa from the USA and other regions between 2000-2005 range from 128.9-33,529 kg (tetraBDE), 226.6-58,929 kg (pentaBDE), 31.3-8,128 (hexaBDE) and 2.0-508 kg. The years 2002 and 2003 recorded the highest import from the other regions and the USA respectively. Since South Africa exports (1994-2005) vehicles to other regions, it is possible that PBDE or other flame retardants were added into vehicles in order to meet trade partner's regulations.

Table 6-22: POP-PBDE in imported vehicles from other regions (2000-2005)

	Total amount POP-PBDEs (kg)	Inventoried POP-PBDE (kg)			
YEAR	Other Regions	tetra-BDE (33%)	penta-BDE (58%)	hexaBDE (8%)	heptaBDE (0.5%)
2000	1135.848	374.8	658.8	90.9	5.7
2001	873.064	288.1	506.4	69.8	4.4
2002	30978.728	10223.0	17967.7	2478.3	154.9
2003	1006.456	332.1	583.7	80.5	5.0
2004	2818.344	930.1	1634.6	225.5	14.1
2005	2543.624	839.4	1475.3	203.5	12.7

Table 6-23: POP-PBDE in imported vehicles from USA (2000-2005)

	Total amount POP-PBDEs (kg)	Inventoried POP-PBDE (kg)			
YEAR	USA	tetra-BDE (33%)	penta-BDE (58%)	hexaBDE (8%)	heptaBDE (0.5%)
2000	390.72	128.9	226.6	31.3	2.0
2001	818.16	270.0	474.5	65.5	4.1
2002	801.84	264.6	465.1	64.1	4.0
2003	101602.48	33528.8	58929.4	8128.2	508.0
2004	1063.84	351.1	617.0	85.1	5.3
2005	1394.16	460.1	808.6	111.5	7.0

6.3.5 Quantities of POP-PBDE in EEE imported into South Africa in 2000-2012

Table 6-24a-6-27a, show the total and per capita amount of CRT for television, CRT for personal computers, ICT for electronic equipment and refrigerators for imported into South Africa in 2000-2012. From the mean POP-PBDE in Tables 6-22a-6-27a, the Σc-OctaBDE in Tables 6-22b-6-25b was calculated based on the fact that c-OctaBDE contains 11% HexaBDE; 43% HeptaBDE and 35% OctaBDE.

Table 6-24a: Total and per capita amount of CRT for TV imported into South Africa in 2000-2012 and the amount of POP-PBDE

TV								
Year	**Total weight [10^3 tonnes]**	**Total number [10^6 units]**	**Population [10^6 capita]**	**CRT weight/person [kg/capita]**	**Number of CRTs/person [units/capita]**	**Minimum POP-PBDE (i) [kg]**	**Maximum POP-PBDE (i) [kg]**	**Mean POP-PBDE (i) [kg]**
	A	**B (A/25)**	**C**	**D (A/C)**	**(B/C)**	**$F_{Polymer}$ = 15%**	**$F_{Polymer}$ = 38%**	**$F_{Polymer}$ = 30%**
2000	3,316.864	132.675	42.9	77.3162	3.0926	0.4329	1.0966	**0.8657**
2001	4,305.735	172.229	44.0	97.8576	3.9143	0.5619	1.4235	**1.1238**
2002	6,512.766	260.511	44.8	145.374	5.8150	0.8500	2.1531	**1.6998**
2003	1,890.62	75.625	45.2	41.8279	1.6731	0.2467	0.6250	**0.4934**
2004	15,124.318	604.973	45.8	330.225	13.209	1.9737	5.0001	**3.9474**
2005	11,134.952	445.398	46.3	240.496	9.6198	1.4531	3.6812	**2.9062**
2006	6,733.243	269.330	46.9	143.566	5.7426	0.8787	2.2260	**1.7574**
2007	34,655.102	1,386.204	47.4	731.120	29.245	4.5225	11.457	**9.0450**
2008	7,036.105	281.444	47.8	147.199	5.8880	0.9182	2.3261	**1.8364**
2009	15,205.559	608.222	48.7	312.229	12.489	1.9843	5.0270	**3.9687**
2010	13,853.598	554.144	49.3	281.006	11.240	1.8079	4.5800	**3.6158**
2011	17,169.978	686.799	50.0	343.400	13.736	2.2407	5.6764	**4.4814**
2012	287.504	11.500	50.6	5.68190	0.2273	0.0375	0.0950	**0.07504**

CRT – Cathod Ray Tube
$M_{PBDE(i)}$ – is the amount of POP-PBDEs (i) in [kg]
$M_{PBDE(i)}$ = [No. Of CRTs/person] x [Population] x [Weight of CRTs/device] x [$f_{polymer}$] x [$C_{c\text{-}OctaBDE;Polymer}$] where:
Weight of CRTs/device estimate average is 25 kg for either TV or PC monitors (EMPA, 2011)
$F_{Polymer}$ – is the total polymer fraction in EEE (Waeger et al., 2008)
$C_{c\text{-}OctaPBDE;Polymer}$ – is the content of the c-OctaPBDE in the polymer fraction of EEE [kg/metric tonnes] for CRT TVs the $C_{c\text{-}OctaPBDE;Polymer}$ = 0.00087 kg/metric tonnes (Waeger et al., 2010)

Table 6-25a: Total and per capita amount of CRT for PCs imported into South Africa in 2000-2012 and the amount of POP-PBDEs

Personal Computers								
Year	**Total weight [10^3 tonnes]**	**Total number [10^6 units]**	**Populatio n [10^6 capita]**	**CRT weight/person [kg/capita]**	**Number of CRTs/person [units/capita]**	**Minimum POP-PBDE (i) [kg]**	**Maximum POP-PBDE (i) [kg]**	**Mean POP-PBDE (i) [kg]**
	A	**B (A/25)**	**C**	**D (A/C)**	**(B/C)**	**$F_{Polymer}$ = 13%**	**$F_{Polymer}$ = 38%**	**$F_{Polymer}$ = 30%**
2000	16,207.297	648.29	42.9	377.79	15.112	5.3516	15.643	**12.350**
2001	16,003.355	640.13	44.0	363.71	14.549	5.2843	15.446	**12.195**
2002	17,016.37	680.65	44.8	379.83	15.193	5.6188	16.424	**12.966**
2003	4,523.613	180.94	45.2	100.08	4.0032	1.4937	4.3662	**3.4470**
2004	56,274.95	2250.9	45.8	1’228.7	49.148	18.582	54.317	**42.882**
2005	26,854.86	1’074.2	46.3	580.02	23.201	8.8675	25.920	**20.463**
2006	24,235.85	969.43	46.9	516.76	20.670	8.0027	23.392	**18.468**
2007	15,469.483	618.78	47.4	326.36	13.054	5.1080	14.931	**11.788**
2008	9,578.91	383.16	47.8	200.40	8.0158	3.1630	9.2456	**7.2991**
2009	9,678.65	387.15	48.7	198.74	7.9496	3.1959	9.3418	**7.3751**
2010	12,136.662	485.47	49.3	246.18	9.8472	4.0075	11.714	**9.2481**
2011	16,837.388	673.50	50.0	336.75	13.470	5.5597	16.251	**12.830**
2012	16,241.733	649.67	50.6	320.98	12.839	5.3630	15.677	**12.376**

CRT – Cathod Ray Tube
$M_{PBDE(i)}$ – is the amount of POP-PBDEs (i) in [kg]
$M_{PBDE(i)}$ = [Weight/person] x [Population] x [Weight of CRTs/device] x [$f_{polymer}$] x [$C_{c\text{-}OctaBDE;Polymer}$] where:
Weight of CRTs/device estimate average is 25 kg for either TV or PC monitors (EMPA, 2011)
$F_{Polymer}$ – is the total polymer fraction in EEE (Waeger et al., 2008);
$C_{c\text{-}OctaPBDE;Polymer}$ – is the content of the c-OctaPBDE in the polymer fraction of EEE [kg/metric tonnes]
for CRT monitors the $C_{c\text{-}OctaPBDE;Polymer}$ = 0.00254 kg/metric tonnes (Waeger et al., 2010)

Table 6-26a: Total and per capita amount of polymer for ICT electronic apparatus imported into South Africa in 2000-2012 and the amount of POP-PBDEs

ICT Electronic Apparatus							
Year	**Total weight [10^3 tonnes]**	**Total number [10^6 units]**	**Population [10^6 capita]**	**weight/person [kg/capita]**	**Minimum POP-PBDE (i) [kg]**	**Maximum POP-PBDE (i) [kg]**	**Mean POP-PBDE (i) [kg]**
	A	**B (A/3.275)**	**C**	**D (A/C)**	**$F_{Polymer}$ = 26%**	**$F_{Polymer}$ = 58%**	**$F_{Polymer}$ = 42%**
2000	6,744,522	2,059,396.0	42.9	157,214.97	3,945.55	8,801.60	**6,373.57**
2001	5,751,747	1,756,258.6	44.0	130,721.52	3,364.77	7,506.03	**5,435.40**
2002	1,527,858	466,521.53	44.8	34,103.973	893.797	1,993.85	**1,443.83**
2003	3,724,681	1,137,307.2	45.2	82,404.447	2,178.94	4,860.71	**3,519.82**
2004	5,128,791	1,566,043.1	45.8	111,982.34	3,000.34	6,693.07	**4,846.71**
2005	7,379,264	2,253,210.4	46.3	159,379.35	4’316.87	9,629.94	**6,973.40**
2006	8,360,229	2,552,741.7	46.9	178,256.48	4,890.73	10,910.1	**7,900.42**
2007	22,108,528	6,750,695.6	47.4	466,424.64	12,933.5	28,851.6	**20,892.6**
2008	6,116,259	1,867,560.0	47.8	127,955.21	3,578.01	7,981.72	**5,779.86**
2009	4,405,753	1,345,268.1	48.7	90,467.207	2’577.37	5,749.51	**4,163.44**
2010	6,640,760	2,027,713.0	49.3	134,701.01	3,884.84	8,666.19	**6,275.52**
2011	8,083,222	2,468,159.4	50.0	161,664.44	4,728.68	10,548.6	**7,638.64**
2012	31,712,268	9,683,135.3	50.6	626,724.66	18,551.7	41,384.5	**29,968.09**

CRT – Cathod Ray Tube
$M_{PBDE(i)}$ – is the amount of POP-PBDEs (i) in [kg]
$M_{PBDE(i)}$ = [Weight/person] x [Population] x [Weight of CRTs/device] x [$f_{polymer}$] x [$C_{c\text{-}OctaBDE;Polymer}$] where: Weight of ICT equipments/device estimate average is 3.275 kg (Huisman et al., 2008; Laffely, 2007; EMPA, 2011)
$F_{Polymer}$ – is the total polymer fraction in EEE (Waeger et al., 2008)
$C_{c\text{-}OctaPBDE;Polymer}$ – is the content of the c-OctaPBDE in the polymer fraction of EEE [kg/metric tonnes] for ICT equipment without monitor $C_{c\text{-}OctaPBDE;Polymer}$ = 0.00225 kg/metric tonnes (Waeger et al., 2010)

Table 6-27a: Total and per capita amount of polymer for refrigerators imported into S.A. in 2000-2012 and the amount of POP-PBDEs

Refrigirators							
Year	**Total weight [10^3 tonnes]**	**Total number [10^6 units]**	**Population [10^6 capita]**	**Weight/person [kg/capita]**	**Minimum POP-PBDE (i) [kg]**	**Maximum POP-PBDE (i) [kg]**	**Mean POP-PBDE (i) [kg]**
	A	**B (A/29.25)**	**C**	**D (A/C)**	**$F_{Polymer}$ = 13%**	**$F_{Polymer}$ = 38%**	**$F_{Polymer}$ = 30%**
2000	13,826,379	472,696.72	42.9	322,293.22	435.531	539.229	**497.750**
2001	16,567,509	566,410.56	44.0	376,534.30	521.877	646.133	**596.430**
2002	15,003,547	512,941.78	44.8	334,900.60	472.612	585.138	**540.128**
2003	572,305.00	19,565.983	45.2	12,661.615	18.0276	22.3199	**20.6030**
2004	38,937,262	1,331,188.4	45.8	850,158.56	1,226.52	1,518.55	**1,401.74**
2005	52,112,511	1,781,624.3	46.3	1,125,540.2	1,641.54	2,032.39	**1,876.05**
2006	61’190’592	2,091,986.1	46.9	1,304,703.5	1,927.50	2,386.43	**2,202.86**
2007	65,049,481	2,223,913.9	47.4	1,372,351.9	2,049.06	2,536.93	**2,341.78**
2008	50,360,181	1,721,715.6	47.8	1,053,560.3	1,586.35	1,964.05	**1,812.97**
2009	49,382,705	1,688,297.6	48.7	1,014,018.6	1,555.56	1,925.93	**1,777.78**
2010	64,232,070	2,195,968.2	49.3	1,302,881.7	,’023.31	2,505.05	**2,312.35**
2011	82,861,222	2,832’862.3	50.0	1,657,224.4	2,610.13	3,231.59	**2,983.00**
2012	882,086.00	30,156.786	50.6	17,432.530	27.7857	34.40135	**31.7551**

CRT – Cathod Ray Tube
$M_{PBDE(i)}$ – is the amount of POP-PBDEs (i) in [kg]
$M_{PBDE(i)}$ = [Weight/person] x [Population] x [Weight of CRTs/device] x [$f_{polymer}$] x [$C_{c\text{-}OctaBDE;Polymer}$] where:
Weight of consumer equipments/device estimate average is 29.25 kg (Laffely, 2007; Furniture re-use network, 2009; EMPA, 2011)
$F_{Polymer}$ – is the total polymer fraction in EEE (Waeger et al., 2008)
$C_{c\text{-}OctaPBDE;Polymer}$ – is the content of the c-OctaPBDE in the polymer fraction of EEE [kg/metric tonnes] for Consumer equipment without monitor the $C_{c\text{-}OctaPBDE;Polymer}$ = 0.00015 kg/metric tonnes (Waeger et al., 2010)

As can be seen in Table 6-24b, the Σc-OctaBDE for hexaBDE, heptaBDE and octaBDE present in televisions range from 0.0083-0.9949 kg, 0.0323-3.8893 kg and 0.0263-3.1657 kg respectively for 2000-2012. The years 2007 and 2012 exhibited the highest and lowest ΣPOP-PBDE (total/year) respectively. For personal computers (Table 6-25b), the Σc-OctaBDE for hexaBDE, heptaBDE and octaBDE calculated range from 0.3792-4.7170 kg, 1.4822-18.439 kg and 1.2064-15.009 kg respectively for 2000-2012; while 2004 and 2003 show the highest and lowest ΣPOP-PBDE (total/year) of 38.165 kg and 3.068 kg respectively. In the case of ICT (Table 6-26b), the Σc-OctaBDE for hexaBDE, heptaBDE and octaBDE range from 158.82-3,296.5 kg, 620.85-12,886 kg and 505.34-10,489 kg respectively. The highest ΣPOP-PBDE (total/year) is recorded for 2012 with a value of 26,671.5 kg and 1284.37 kg recorded for 2002. The Σc-OctaBDE in refrigerators (Table 6-27b) is distributed as follows: hexBDE (2.266-328.13 kg); heptaBDE (8.859-1,007 kg) and octaBDE (7.21-1,044.1 kg). The year 2003 shows the lowest ΣPOP-PBDE (total/year) with a value of 18.366 kg and the highest value of 2,654.9 kg for the 2011. Of all the electronic and electrical equipment, ICT electronics recorded the highest c-OctaBDE with the highest value of 7,031.95 kg. This is followed by refrigerators with the highest value of 2,057.99 kg. The highest recorded c-OctaBDE in personal computers (CRT) and televisions (CRT) are 38.17 kg and 8.049 kg respectively. The highest c-OctaBDE in electronic and electrical equipment is recorded for the following years: 2007 (TV); 2004 (PC); 2006 (ICT) and 2011 (refrigerators).

Table 6-24b: c-OctaBDE composites present in TVs (mainly HexaBDE and HeptaBDE)

Inventory c-OctaBDE		POP-PBDEs in import for inventory												
Homologues	Distribution homologues c-OctaBDE	∑c-OctaBDE (kg)												
		2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
HexaBDE	11%	0.0952	0.1236	0.1870	0.0543	0.4342	0.3197	0.1933	0.9949	0.2020	0.4366	0.3977	0.4930	0.0083
HeptaBDE	43%	0.3723	0.4832	0.7309	0.2122	1.6974	1.2497	0.7557	3.8893	0.7897	1.7065	1.5548	1.9270	0.0323
OctaBDE	35%	0.3030	0.3933	0.5950	0.1727	1.3816	1.0172	0.6151	3.1657	0.6427	1.3890	1.2655	1.5685	0.0263
ΣTotal/year		**0.7705**	**1.0001**	**1.5129**	**0.4392**	**3.5132**	**2.5866**	**1.5641**	**8.0499**	**1.6344**	**3.5321**	**3.218**	**3.9885**	**0.0669**

Table 6-25b: c-OctaBDE composites present in PCs (mainly HexaBDE and HeptaBDE)

Inventory c-OctaBDE		POP-PBDEs in import for inventory												
Homologues	Distribution homologues c-OctaBDE	∑c-OctaBDE (kg)												
		2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
HexaBDE	11%	1.3585	1.3414	1.4263	0.3792	4.7170	2.2510	2.0314	1.2967	0.8029	0.8113	1.0173	1.4113	1.3614
HeptaBDE	43%	5.3105	5.2437	5.5756	1.4822	18.439	8.7993	7.9411	5.0687	3.1386	3.1713	3.9767	5.5169	5.3218
OctaBDE	35%	4.3225	4.2681	4.5383	1.2064	15.009	7.1622	6.4637	4.1257	2.5547	2.5813	3.2368	4.4905	4.3317
ΣTotal/year		**10.9915**	**10.8532**	**11.5402**	**3.0678**	**38.165**	**18.2125**	**16.4362**	**10.4911**	**6.5223**	**6.5639**	**8.2308**	**11.419**	**11.015**

Table 6-26b: c-OctaBDE composites present in ICT electronics (mainly HexaBDE and HeptaBDE)

Inventory c-OctaBDE		POP-PBDEs in import for inventory												
Homologues	**Distribution homologues c-OctaBDE**	∑c-OctaBDE (kg)												
		2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
HexaBDE**	11%	701.09	597.89	158.82	387.18	533.14	767.07	869.05	2,298.2	635.79	457.98	690.31	840.25	3,296.5
HeptaBDE**	43%	2,740.6	2,337.2	620.85	1,513.5	2,084.1	2,998.6	3,397.2	8,983.8	2,485.3	1,790.3	2,698.5	3,284.6	12,886
OctaBDE*	35%	2,230.8	1,902.4	505.34	1,231.9	1,696.3	2,440.7	2,765.1	7,312.4	2,023.0	1,457.2	2,196.4	2,673.5	10,489
ΣTotal/year		**5,672.49**	**4,837.49**	**1,285.01**	**3,132.58**	**4,313.54**	**6,206.37**	**7,031.95**	**1,859.44**	**5,144.09**	**3,705.48**	**5,585.21**	**6,798.35**	**2,667.15**

Table 6-27b: c-OctaBDE composites present in refrigerators (mainly HexaBDE and HeptaBDE)

Inventory c-OctaBDE		POP-PBDEs in import for inventory												
Homologues	**Distribution homologues c-OctaBDE**	∑c-OctaBDE (kg)												
		2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
HexaBDE	11%	54.75	65.607	59.414	2.266	154.19	206.37	242.31	257.60	199.43	195.56	254.36	328.13	3.493
HeptaBDE	43%	214.03	256.47	232.25	8.859	602.75	806.70	947.23	1,007.0	779.58	764.43	994.31	1,282.7	13.655
OctaBDE	35%	174.21	208.75	189.04	7.211	490.61	656.62	771.00	819.62	634.54	622.22	809.32	1,044.1	11.114
ΣTotal/year		**442.99**	**530.83**	**480.704**	**18.336**	**1,247.55**	**1,669.69**	**1,960.54**	**2,084.22**	**1,613.5**	**1,582.21**	**2,057.99**	**2,654.9**	**28.262**

6.4 Determination of POP-PBDE in landfill sediments and leachates

6.4.1 PBDE in landfill sediment

As indicated earlier, analysis of leachate and sediment samples from Chloorkop, Garskloof, Hatherly, Onderstepoort, Robinson deep and Soshanguve in Gauteng was undertaken to determine the presence and levels of POP chemicals. These landfill sites were sampled based on the production of leachates as well as accessibility. Garskloof, Hatherly, Onderstepoort and Soshanguve are based in Pretoria, Chloorkop and Robinson deep are in Johannesburg. Landfill sites in Gauteng Province were chosen because of (1) high industrial activities in the province and (2) convenience with respect to sample collection. So far only PBDEs were analysed since the standards were available at the time of sampling.

In the sediment samples from Hatherly and Soshanguve landfill sites, all the PBDEs were detected in all the sites except PBDE-183 in Soshanguve as can be seen in Figure 6-1. PBDE-47 exhibited the highest concentration of 0.54 ng g^{-1}. This was followed by PBDE-99 and PBDE154 with concentrations of 0.25 ng g^{-1}. The PBDEs levels observed for Hatherly site was generally higher than the values for Soshanguve. The detection of PBDE-17, PBDE-47, PBDE-99 and PBDE-153 in all the samples indicated that these were the most common BFRs in the samples analysed. One could, therefore, suggest that these congeners can be used as preliminary screening indicators of BFRs contamination in environmental matrices. PBDE-47, 99, 100, 153, 154, 183 and 209 were all detected from the landfill sites sampled. The highest value (4.2 ng g^{-1}) was recorded for PBDE 209 from Garkloof (Figure 6-2). This was followed by PBDE-153 from Robinson deep (3.8 ng g^{-1}).
Garskloof landfill site is one of the oldest landfill sites within the City of Tshwane Metropolitan Municipality and handles about 45, 000 ton/month of building, garden and household wastes. Large volume and different types of waste dumped into Garskloof may have contributed to the observed high values. PBDE 209 was the highest in Onderstepoort landfill site. Hatherly showed the lowest least BDE values compared to other sites.

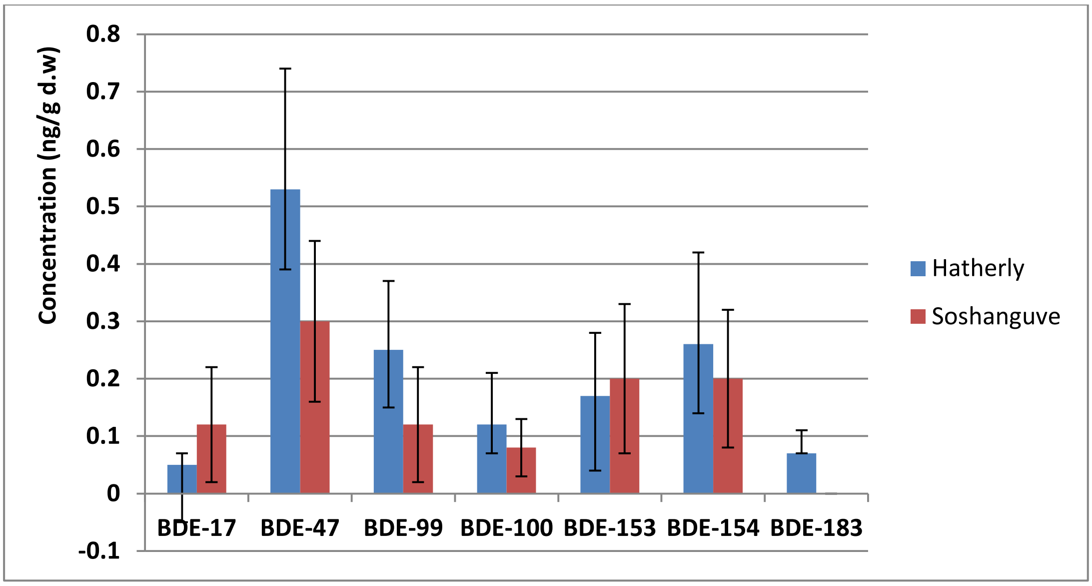

Figure 6-1: PBDE concentrations in landfill sediments from two landfill sites (2013 summer)

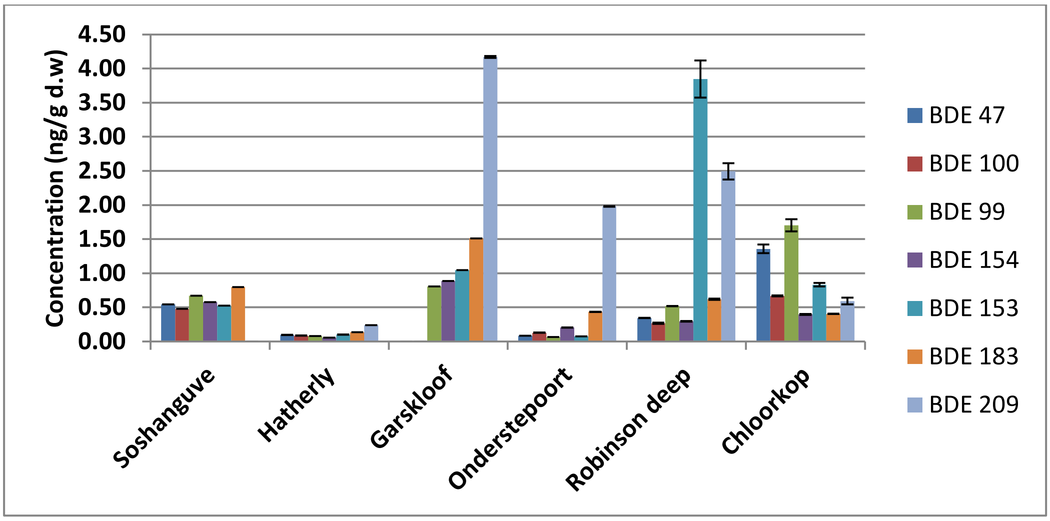

Figure 6-2: PBDE concentrations in landfill sediment (2013 winter)

Figure 6-3 shows PBDE concentrations in leachate samples collected in summer from Hatherly and Soshanguve. As can be seen from Figure 6-3, PBDE-47 exhibited the highest concentrations from both landfill sites. The order for the other congeners was as follows: BDE-153> BDE-99>154>100.17>183. BDE-209 was not detected in leachate samples from either of the landfill sites. Generally, the BDE levels in Hatherly were significantly higher than the levels in Soshanguve.

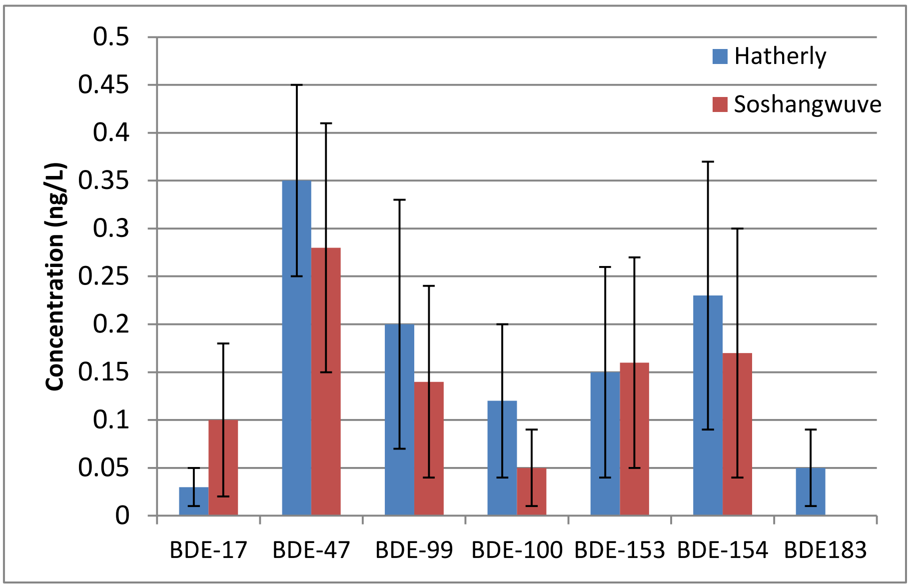

Figure 6-3: PBDE concentrations in landfill leachate samples (2013summer)

PBDE-47, 99, 100, 153, 154, 183 and 209 were all detected in the leachate samples as can be seen in Figure 6-4. PBDE-209 was the highest overall concentration of 1.9 ng g^{-1} for Chloorkop. This was followed by BDE-100 with a concentration of 1.32 ng g^{-1}. BDE-47 was detected at a concentration level of 0.98 ng g-1 from Chloorkop and this was followed by BDE209 (0.51 ng g^{-1}) for Robinson deep. The values recorded for winter leachates samples were significantly higher than BDE levels recorded for summer samples. Dilution effect as a result of infiltration of rain into the landfills may have contributed to the observed values.

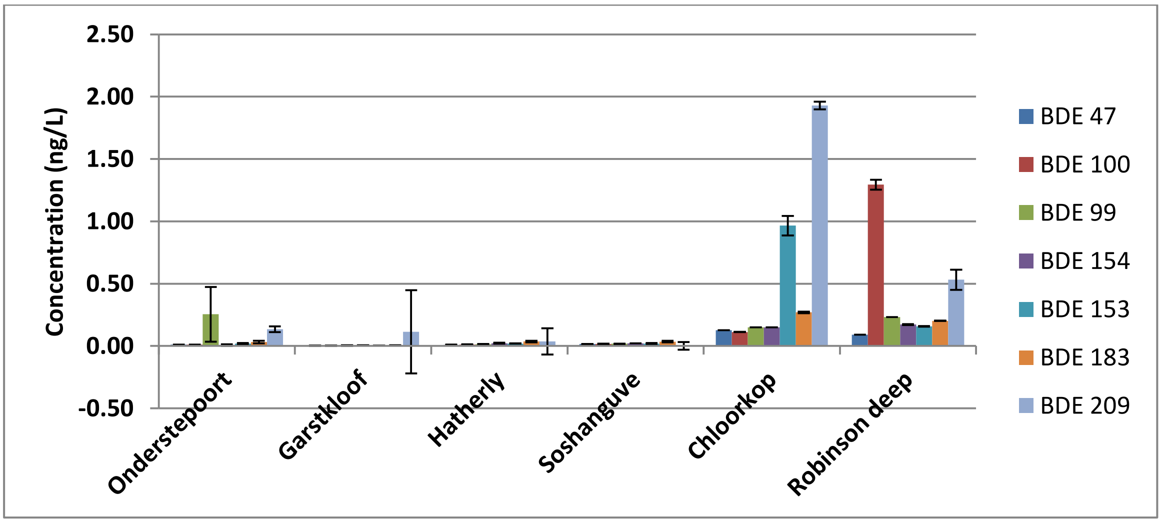

Figure 6-4: PBDE concentrations in landfill leachates samples (2013winter)

6.5 Quantities of possible brominated ethers POPs imported into South Africa in 2007-2011

The quantities of possible brominated ethers POPs imported into South Africa in 2007-2011 are shown in Table 6-28. As can be seen in Table 6-28, the quantities have been grouped into codes A, B and C. From the quantities, it is extremely difficult to ascribe any quantity to PBDEs or PFOS. However, a total of 1, 776, 263 kg, 263 990 kg and 71, 478 kg is recorded for categories A, B and C respectively.

Table 6-28: Possible brominated ethers of the listed chemicals imported into South Africa (the dti trade data, 2012)

YEAR	QUANTITY/kg BROMINATED ETHERS		
	A	B	C
1988	-	44,928	2,090
1989	-	24,578	2,202
1990	-	3,771	10,834
1991	-	47,176	5,418
1992	-	26,082	4,169
1993	-	51,930	14,422
1994	-	62,600	30,132
1995	50,408	2,925	1,811
1996	85,630	-	-
1997	159,987	-	-
1998	98,881	-	-
1999	327,927	-	-
2000	291,788	-	-
2001	71,840	-	-
2002	39,560	-	-
2003	34,522	-	-
2004	111,500	-	-
2005	99,051	-	-
2006	64,338	-	-
2007	150,734	-	-
2008	100,489	-	-
2009	83,365	-	-
2010	6,243	-	-
2011	-	-	400
TOTAL	**1,776,263**	**263,990**	**71,478**

[A] H29093000: Ethers, ether-alcohols, ether-phenols, ether-alcohol-phenols, alcohol perox- ides, ether peroxides, ketone peroxides (whether or not chemically defined), and their **halogenated**, sulphonated, nitrated or nitrosated derivatives: aromatic ethers;

[B] H29093010: Ethers, ether-alcohols, ether-phenols, ether-alcohol-phenols, alcohol perox- ides, ether peroxides, ketone peroxides (whether or not chemically defined), and their **halogenated**, sulphonated, nitrated or nitrosated derivatives: aromatic ethers and

[C] H29093020: Ethers, ether-alcohols, ether-phenols, ether-alcohol-phenols, alcohol perox- ides, ether peroxides, ketone peroxides (whether or not chemically defined), and their **halogenated,** sulphonated, nitrated or nitrosated derivatives: halogenated, [C]

6.6 Conclusion

In this chapter, conclusions are drawn from the results obtained from information gathered using Tier 1 (initial assessment) method. The current study was able to show:

- Quantities of POP-PBDEs in various EEE and WEEE products;
- Σc-OctaBDE in stock, stock entering into the waste stream and polymer fractions (recycling) were determined;
- The order of Σc-OctaBDE in electronic and electrical equipment were: ICT>refrigerators>PC>TV;
- Σc-OctaBDE and Σc-PentaBDE in imported cars into South Africa from the USA and other regions in 2000-2005;
- Analysis of leachate and sediment samples from six landfill sites showed the presence of PBDEs and, therefore, these sites can be confirmed to be contaminated with one of the ten new POP chemicals, PBDEs and
- Quantities of POP-PBDE imported in form of chemicals or formulation.

CHAPTER 7: INVENTORY OF LISTED NEW POPS USED AS INDUSTRIAL AND AGRICULTURAL CHEMICALS

7.1 Introduction

The current report focuses on the results obtained so far on the listed POP chemicals, particularly on obsolete pesticides namely, endosulfan and lindane; PBDEs, PFOS and its related salts imported and exported into and out of South Africa in 2010-2013.

7.2 Methodology

The Tier 1 (initial assessment) approach was used to collate information. Visits to stakeholders were also undertaken. Verification exercise was conducted on data obtained from **the dti** and external sources such as UNcomtrade. The harmonized codes for the industrial chemicals and pesticides imported and exported into and out of South Africa were used to identify POPs chemicals and their respective quantities.

7. 3 Results and Discussion

7.3.1 Import and export of POPs chemicals

Of all the imported POPs chemicals in 2010-2013, PFOS imported into South Africa increased from <5, 000 kg in 2010 to 15, 000 kg in 2011, 20, 000 kg in 2012 and 25, 000 kg in 2013 (Figure 7.1). A significant increase (10, 000 kg) occurred in 2010-2011 and, thereafter, a steady increase of 5, 000 kg/year was observed. The observed increase in PFOS imported into South Africa is an indication of the demand for the chemical. This was followed by PFOSF with <2,500 kg in 2010-2011. A steady decline in the importation of PFOSF occurred in 2011-2013. This is probably an indication of decline in demand for the chemical. The quantities of c-PentaBDE imported were <1000 kg in 2011, 2012 and 2013 and far less than 1000 kg in 2010. The import trend with c-PentaBDE, although increased marginally in 2010-2011, remained the same in 2011-2013. With respect to TetraBDE and chlordecone, quantities far less than 1000 kg was recorded in 2011-2012 and none in 2010 and 2013. PFOS accounted for a total of 93.87%; while others (PFOSF, PeCB, PentaBDE, TetraBDE, β-HCH and chlordecone) accounted for 6.13%.

With respect to exported POPs chemicals, 5,000 kg was recorded for PFOS in 2010 and later peaked up at 22, 000 kg in 2011 and declined to 10, 000 kg in 2012 and finally 8, 000 kg in

2013 (Figure 7.2). The second highest POPs chemical was β-hexachlorocyclohexane with a value of 10, 000 kg in 2012. No values were recorded in 2010, 2012 and 2013 for β-hexachlorocyclohexane. PFOSF was the third highest POP chemical with a value of 5, 000 kg in 2011 and, thereafter, declined to 2, 500 kg in 2012 and <2, 000 kg in 2013. β-HCH and others (PeCB, PentaBDE, TetraBDE, and chlordecone) accounted for 77.61%, 16.59% and 5.80% respectively.

7.3.2 Perfluorooctane sulphonate (PFOS)

The total quantities (kg) of PFOS imported and exported into and out of South Africa in 2010-2013 amounted to 72,333 kg and 67,720 kg respectively. PFOS imported into South Africa (Figure 7-1) increased from <5, 000 kg in 2010 to 15, 000 kg in 2011, 20, 000 kg in 2012 and 25, 000 kg in 2013. A significant increase (10, 000 kg) occurred in 2010-2011 and, thereafter, a steady increase of 5, 000 kg/year was observed. The observed increase in PFOS imported into South Africa is an indication of the demand for the chemical. However, the quantities of PFOS exported (Figure 7-2) into South Africa was about 5, 000 kg in 2010, increased dramatically in 2011 to 23, 000 kg and, thereafter, declined to 10, 000 kg in 2012 and finally about 8, 000 kg in 2013.

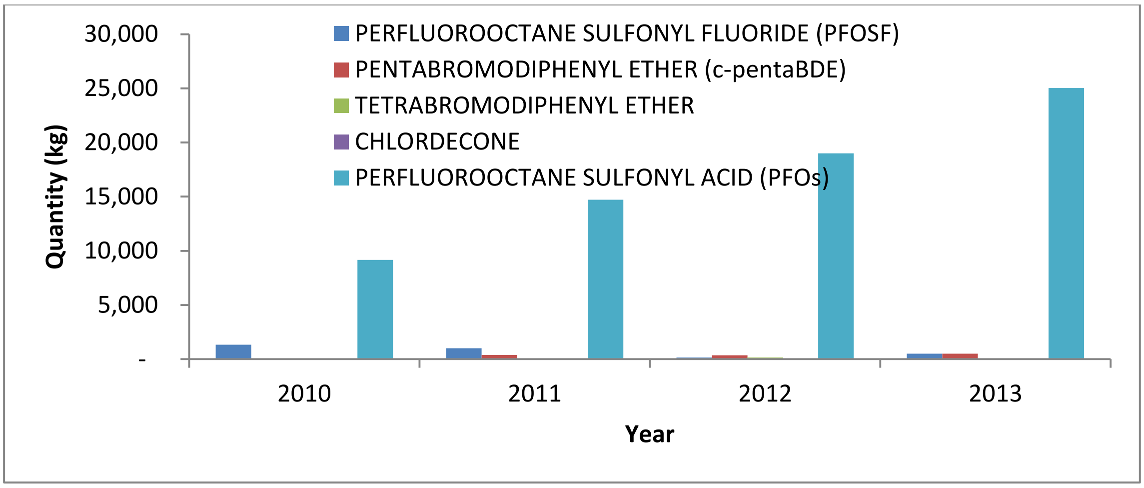

Figure 7-1: Sum quantities of POP chemicals imported into South Africa (2010-2013)

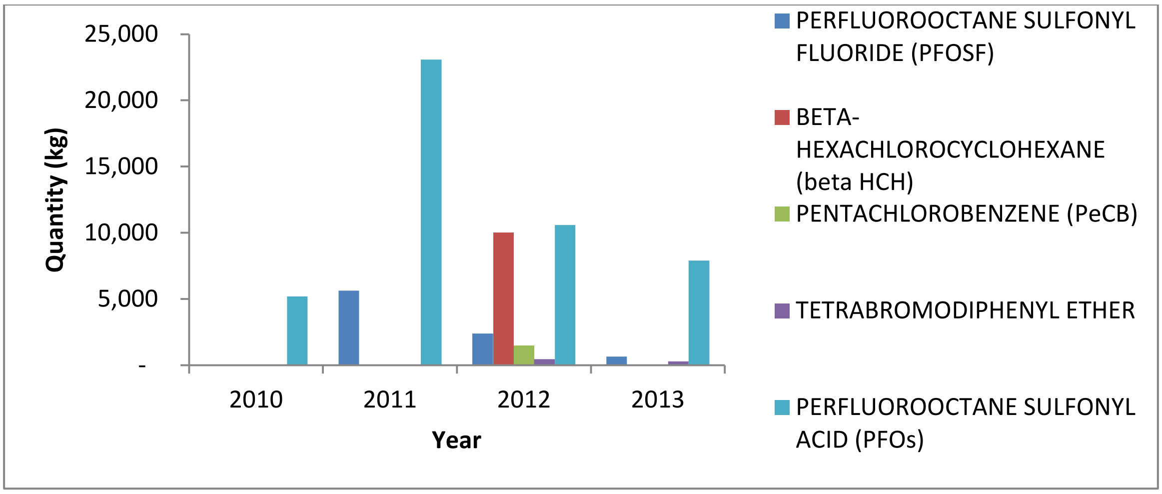

Figure 7-2: Sum quantities of POPs chemicals exported from South Africa (2010-2013)

7.3.3 Perchlorooctane sulphonyl fluoride (PFOSF)

The total quantities of PFOSF imported into South Africa were 3, 024 kg. The quantity of PFOSF imported (Figure 7-1) in 2010 was <2, 000 kg and since then has been on the decline. A steady decline in the importation of PFOSF occurred in 2011-2013. This is probably an indication of decline in demand for the chemical. However, the quantity exported (Figure 7-2) in 2011 amounted to about 5, 000 kg, although this has declined to <2, 000 kg in 2013. This is rather surprising since import in 2011 was significantly lower than export in the same year. This unprecedented pattern can only suggest the exportation of stockpile or that some local production may be taking place.

7.3.4 Perfluorooctane sulphonate (PFOS) in Fire extinguishers

Most of the companies contacted during the survey indicated that fire extinguishers containing PFOS were phased out 10 years ago. Most of the companies in the fire industries indicated that they get their formulations from chemical giants such as Chemserve. Material datasheets indicated that chemicals used in fire extinguishers currently in South Africa do not contain PFOS.

7.3.5 Beta-hexachlorohexane (β-HCH)

The quantities of β-HCH imported into South Africa from 2011-2013 remained the same at <1, 000 kg (Figure 7-1). However, a different pattern was observed for the export (Figure 7-2) whereby the quantity exported peaked at 10, 000 kg in 2012. Little or no importation was observed in 2010, 2011 and 2013. A total of 10, 000 kg were exported to the Democratic Republic of Congo (DRC). Quantities for import were not given. This probably suggests that stock β-HCH from previous years may have accounted for the observed increase in export or that the chemical is produced in South Africa.

7.3.6 Pentachlorobenzene (PeCB)

No values were obtained for the importation of PeCB. However, a total amount of 1, 500 kg was exported (Figure 7.1). Again, unaccounted stockpile of PeCB may have accounted for the observed discrepancy between import and export.

7.3.7 Pentabromodiphenyl ether (PentaBDE)

A total of 1, 273 kg was imported (Figure 7-1) into South Africa from China and the United Kingdom. The amount imported from China accounted for 88%; while that from the United Kingdom accounted for only 12%. No export values were given. Unaccounted stockpile of PeCB may have accounted for the observed discrepancy between import and export.

7.3.8 Tetrabromodiphenyl ether (TetraBDE)

A total of 131 kg of TetraBDE was imported into South Africa from Germany and the United Kingdom, while 750 kg was exported to Peru in 2012. Again, the amount imported was by far less than the amount exported (Figure 7-1-7-2).

7.3.9 Chlordecone

Only 4 kg was recorded for the total amount of chlordecone imported into South Africa from the United Kingdom in 2010-2013. No export was recorded.

7.3.10 Quantities of imported and exported POPs chemicals

Of all the imported POPs chemicals in 2010-2013, PFOS accounted for a total of 93.87%; while others (PFOSF, PeCB, PentaBDE, TetraBDE, β-HCH and chlordecone) accounted for 6.13%. With respect to exported POPs chemicals, PFOS, β-HCH and others (PeCB, PentaBDE, TetraBDE, and chlordecone) accounted for 77.61%, 16.59% and 5.80%

respectively. The percentage distribution of POPs chemicals imported and exported into and out of South Africa in 2010-2013 is shown in Figures 7-3-7-4.

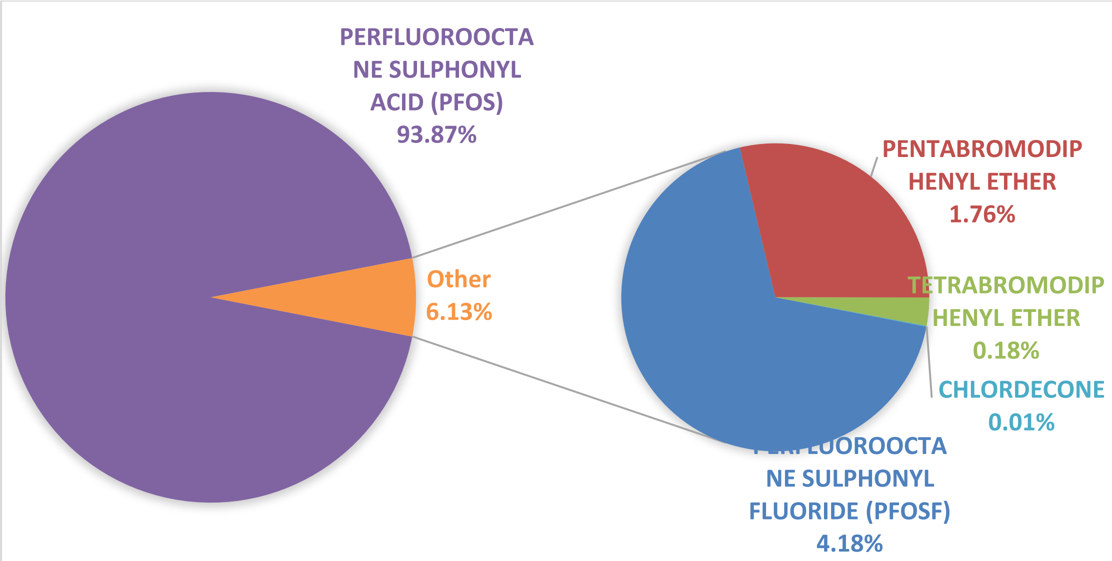

Figure 7-3: Percentage distribution of POPs chemicals imported into S.A (2010-2013)

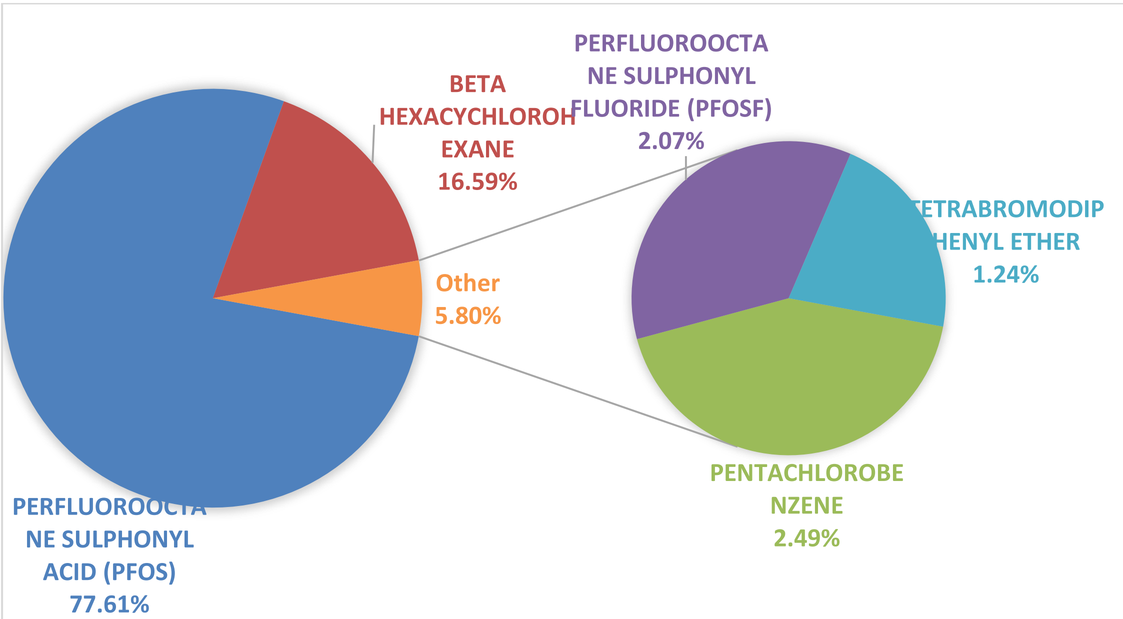

Figure 7-4: Percentage distribution of POP chemicals exported out of SA (2010-2013)

Since PFOSF and PFOS accounted for the highest quantities of POPs chemicals imported, they have been plotted to show the quantities imported from different countries (Figures 7.5-7.6).

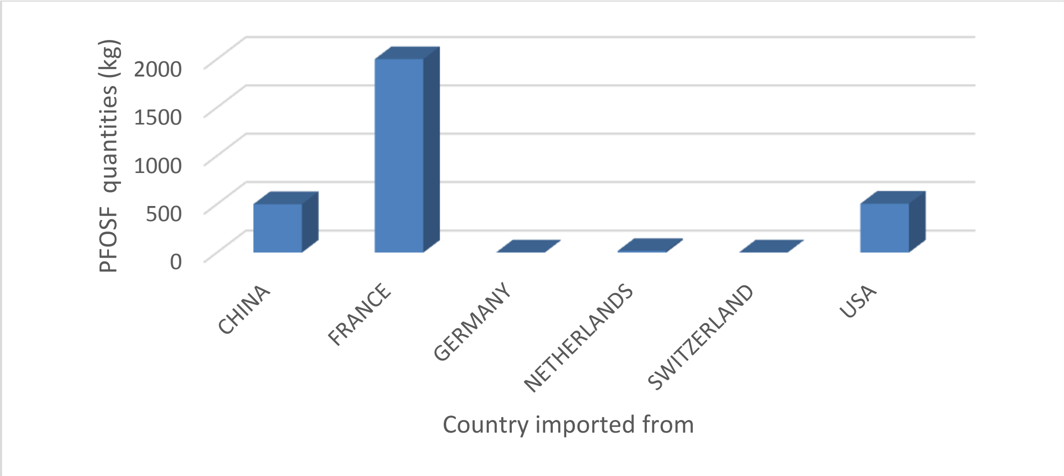

Figure 7.4: Quantities of perfluorooctane sulphonyl fluoride (PFOS) imported into South Africa from different countries in 2010-2013

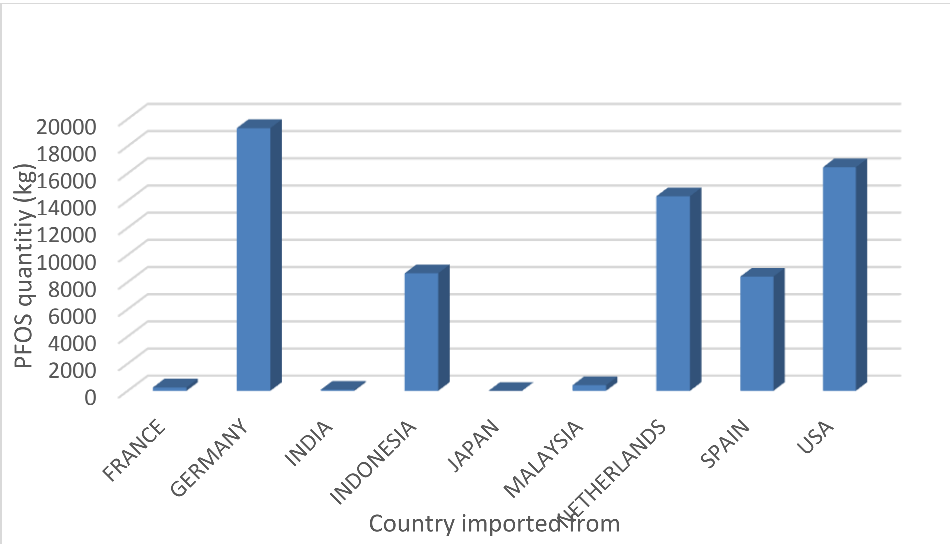

Figure 7.5: Quantities of perfluorooctane sulphonyl acid (PFOSA) imported into South Africa from different counhtries in 2010-2013

Figures 7.6-7.7 show quantities of PFOSF and PFOS exported to different countries from South Africa.

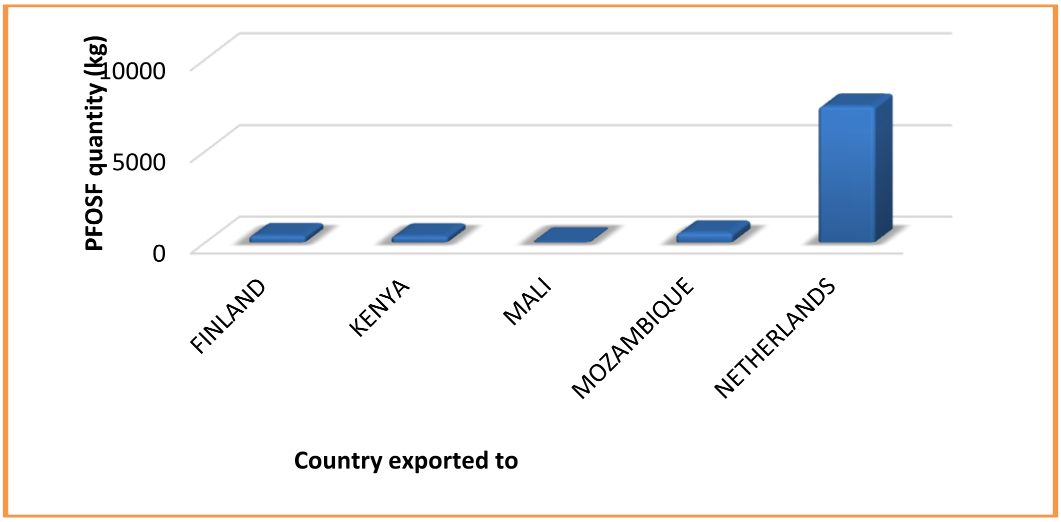

Figure 7.6: Quantities of perfluorooctane sulphonyl fluoride (PFOSF) exported to different countries from South Africa in 2010-2013

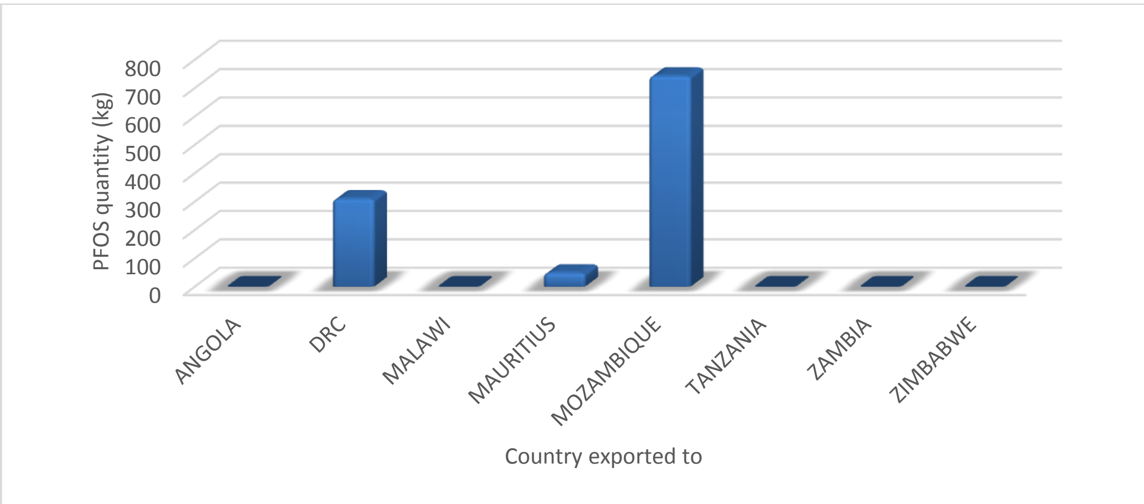

Figure 7.7: Quantities of perfluorooctane sulphonyl acid (PFOS) exported to different countries from South Africa in 2010-2013

7.4. Verification

Data obtained from UNcomtrade on lindane was compared to the data from the dti and the two are in agreement in 2007-2010 on importation of lindane. Also data on obsolete pesticides reported in the present report was updated in 2012. Further verification is anticipated during the stakeholder's inventory report.

7.5 Conclusion

From this chapter:

➢ Large quantities of Stockholm Convention listed POP chemicals have been imported into and exported from South Africa;

- PFOS accounted for more than 90% of POP chemicals imported into South Africa;
- PFOS and its related salts are imported and exported into and from South Africa; and
- Verification of data was done by comparing the data obtained from UNcomtrade and the dti.

CHAPTER 8 INVENTORY OF POP PESTICIDES

8.1 Introduction

This part of the report focuses on the results obtained on the listed POP chemicals, particularly on obsolete pesticides namely, endosulfan, lindane, chlorodecone/kepone, α-hexachlorocyclehexane and β-hexacyclehexane imported and exported into and out of South Africa in 2010-2013 and obsolete stocks at various sites.

8.2 Methodology

The Tier 1 and II approachs were used to collate information presented in the current report. Telephone calls and emails were used to contact stakeholders to provide information on the ten new POPs. Visits to stakeholders were also undertaken.

8.3 Results and Discussion

8.3.1 Imports and Exports of Lindane

Tables 8-1 and 8-2 show data obtained from UNcomtrade and the dti on lindane. As can be seen from the tables, there is reasonable agreement between the two tables in 2007-2010 on importation of lindane into South. Also data on obsolete pesticides reported in the present report was updated in 2012.

Table 8-1: Import and Export data of Lindane by South Africa (UNcomtrade, 2013)

Year		2007	2008	2009	2010	2011
Quantity/kg	Import	33, 974	24	168	348	189
	Export	-	8,750	10	140	265

Table 8-2 shows the quantities of lindane and pentachlorobenzene and its derivatives imported into South Africa in 1988-2011. The quantities of lindane and pentachlorobenzene and their derivatives imported into South Africa peaked in 1996 and 1995 in the region of 1, 075, 460 kg and 2,962,999 kg respectively. Thereafter, the quantities of lindane imported into South Africa decreased drastically in 2008 and appears to be on the rise up to 2010. It is possible that importation of lindane up to 2011 could be attributed to its use in hair shampoo formulation for lice. This claim, however, needs to be confirmed with the Department of Health. In the case of pentachlorobenzene and its derivatives, the use declined by about 50% compared to the quantity in 1995. The total quantities of lindane and pentachlorobenzene and its derivatives imported into South Africa in 1988-2011 came to 1, 409, 695 kg and 24, 678, 541 kg respectively.

Table 8-2: Lindane and Pentachlorobenzene imports into South Africa (1988-2011) (dti import data 2013)

YEAR	Imports **QUANTITY/kg**	
	LINDANE	**PENTACHLOROBENZENE AND ITS DERIVATIVES**
1988	1,000	779,320
1989	1,000	852,730
1990	7,050	903,709
1991	17,600	883,648
1992	26,503	1,089,982
1993	22,701	1,393,839
1994	30,400	1,259,704
1995	11,598	2,962,999
1996	1,075,460	1,365,513
1997	18,150	944,855
1998	29,002	990,639
1999	17,026	1,177,197
2000	10,358	866,954
2001	40,049	1,019,586
2002	6,215	105,958
2003	17,604	848,309
2004	12,018	106,877
2005	26,279	1,169,806
2006	5,200	1,048,750
2007	33,974	1,206,579
2008	20	1,029,309
2009	168	112,073
2010	320	1,096,422
2011	-	1,463,783
TOTAL	**1,409, 695**	**24,678,541**

The import values reported in Table 8-1 are in agreement with the values in Table 8-2.

8.4.2 Obsolete Pesticides

Information on obsolete endosulfan and lindane, *inter alia*, obtained from obsolete pesticide data for 2012 are shown in Table 8-3. The quantities of endosulfan and lindane ranged from 0.02-175 kg and 0.02-500 kg respectively. Clanwilliam and Stellenbosch recorded the highest and lowest quantities of 175 kg and 0.02 kg) respectively. In the case of lindane the highest (500 kg) and lowest (0.02 kg) quantities were recorded for De Aar and Stellenbosch respectively. Quantities of endosulfan from other areas include: 35 kg (Bethlehem); 10 kg (Franchhoek); 25 kg (Heilbron); 25 kg (Kaapse Wynland); 30 kg (Kaapstad); 25 kg (Koelenhof); 2 kg (Marble Hall); 20 kg (Riversonderend); 3 kg (Robbertson); 5 kg (Somerset Wes) and 20 kg (Wellington). With respect to lindane, the following quantities were recorded: 1-5 kg (Bethlehem) and 0.15 kg (Potchefstroom). Stellenbosch recorded 0.02 kg of γ-HCH.

Table 8-3: Quantities of obsolete Endosulfan/Endosulfan formulations in store per district in South Africa (AVCASA obsolete 2012)

District	Product Name	Size	Unit	Qty
Bethlehem	Endosulfan	25	L	35
Caledon	Thionex	25	L	7
Clanwilliam	Endosulfan 5% DP	25	KG	175
Clanwilliam	Thiodan	25	KG	28
Elgin	Thionex	25	L	30
Elgin	Thionex SC	25	L	20
Franchhoek	Endosulfan	25	L	10
Grabouw	Thionex	20	L	7
Greyton	Thionex (Litres)	1	L	0.1
Groot Drakenstein	Thionex (Litres)	25	L	15
Hartswater	THIODAN		KG	15
Heilbron	Endosulfan	25	L	25
Heilbron	Thionex	25	L	150
Kaapse Wynland	BHC Dip	1	KG	1
Kaapse Wynland	Endosulfan WP	5	KG	2.5
Kaapse Wynland	Thionex SC	5	L	5
Kaapstad	Endosulfan	5	KG	30
Kaapstad	Endosulfan	25	KG	30
Koelenhof	Endosulfan	25	KG	25
Kuilsrivier	Thionex (Litres)	25	L	18
Marble Hall	Endosulfan	1	L	2
Oudtshoorn	Thiodan	25	KG	85
Paarl	Thiodan	5	KG	20
Paarl	Thionex	5	L	34
Riviersonderend	Endosulfan 50 DP	25	KG	20
Riviersonderend	Thionex	25	L	4
Robertson	Endosulfan	5	L	3
Robertson	Endosulfan WP	25	KG	12
Robertson	Thiodan WP	5	KG	1
Robertson	Thionex	25	L	25
Somerset Wes	Endosulfan	5	L	5
Stellenbosch	Endosulfan	0.024	KG	0.02
Stellenbosch	Endosulfan Sulfate	0.017	KG	0.14
Stellenbosch	Gamma HCH	0.016	KG	0.02
Stellenbosch	Thionex	25	L	50
Stellenbosch Wynland	Thiodan WP	5	KG	2
Swellendam	Thiodan WP	25	KG	20
Theewaterskloof	Thionex	25	L	1
Wellington	Endosulfan	25	L	20
Wellington	Thiodan WP	5	KG	7
Witzenberg	Thiodan	20	L	11
Wolseley	Thiodan BP	20	KG	20
Wolseley	Thiodan WP	2	KG	8

Tables 8-4 shows data obtained from AVCASA obsolete report of February 2012. The largest quantity of obsolete Lindane was was at De Aar (500 kg) followed by Bthethlehem (5 kg) and Paul Roux (3 kg). The other sites had obsolete Lindane stocks of one kilogram or less (Table 8-4)

Table 8-4: Quantities of obsolete Lindane/Lindane formulation in store per district in (South Africa (AVCASA obsolete report, 2012)

District	Product Name	Size	Size Unit	Qty
De Aar	BHC	25	KG	500
Bethlehem	Lindaan DS	5	KG	5
Bethlehem	Lindane 250 EC	25	L	1
Kaapse Wynland	BHC Dip	1	KG	1
Paul Roux	Lindastof	5	KG	3
Potchefstroom	Lindane DP	0.5	KG	0.15
Stellenbosch	Lindane DP	25	KG	13.2
Stellenbosch	Gamma HCH	0.016	KG	0.02
Stellenbosch	Lindane	0.024	KG	0.02

8.5 Conclusions

- Obsolete POP pesticides are still available in South Africa;
- Endosulfan was by far the higher quantity and
- Despite the fact that registration of lindane has been withdrawn years ago, the dti trade data indicate that it is still being imported and exported into and from South Africa to date. Although prohibited for use as agricultural and stock remedies, it is possible that it is being applied in pharmaceutical formulation in hair shampoo for the eradication of lice.

CHAPTER 9: APPLICATIONS OF POP PESTICDES ON AGRICULTURAL CROPS

9.1 Introduction

The current chapter focuses on the results obtained so far on the application of endosulfan on various agricultural crops in South Africa

9.2 Methodology

The Tier 1 and II approaches were used to collate the information presented in the current report. Telephone calls and emails were used to contact stakeholders to provide information on the ten new POPs.

9.3 Results and Discussion

9.3.1 Historical use of Endosulfan in South Africa

The historical data on the use of endosulfan and its formulations in crops in South Africa in 2006-2012 is shown in Figures 9.1-9.6. The use of endosulfan in South Africa was most prevalent in maize crops in 2006-2012 and showed a decreasing trend since then. The inclusion of endosulfan in Annex III of Rotterdam Convention in 2007 (UNEP/FAO/RC/COP.4/9, 2007) could have necessitated the new behaviour of utilisation.

Generally, endosulfan was widely applied to maize to prevent pesticides such as stock-borers and armyworms. The quantities of endosulfan applied to maize decreased from 128,744 L in 2006 to 3840 L in 2012, indicating 97% decrease. By 2012, application of endosulfan in maize crops was still the dominant consumption of endosulfan in South Africa. The second largest consumer of endosulfan was fruity crops (Figure 9.1).

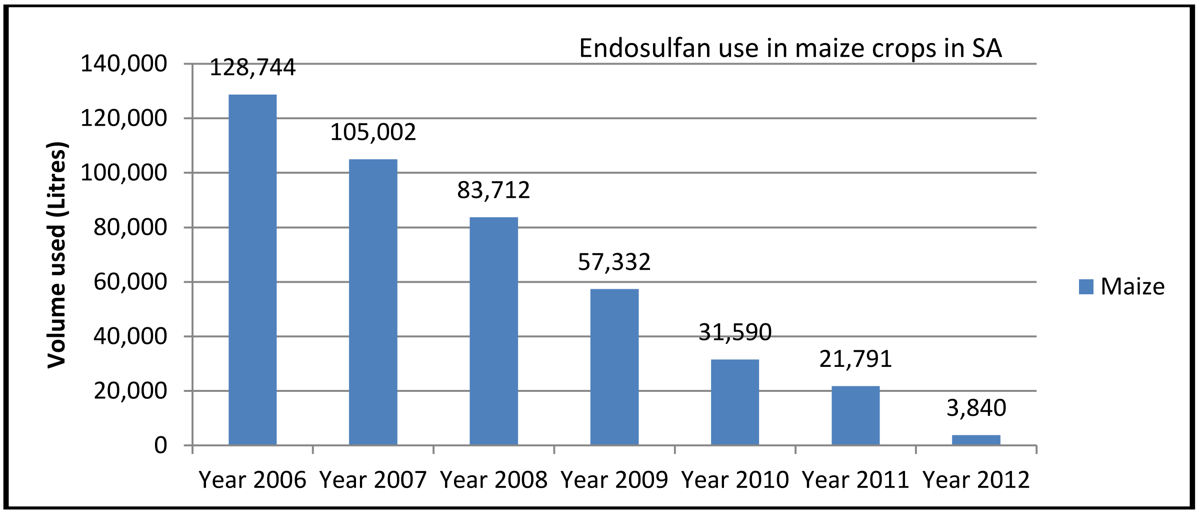

Figure 9.1: Quantities of endosulfan formulations used in maize crops in 2006-2012 in South Africa (Source: AVCASA historical data)

Figure 9.2 shows the application of endosulfan on other agricultural crops. The largest quantity was used on groundnut in 2011, followed by groundnut in 2010 and capsicum in 2006. Approximately, 500 L were used on sweet lupins and canola in 2009.

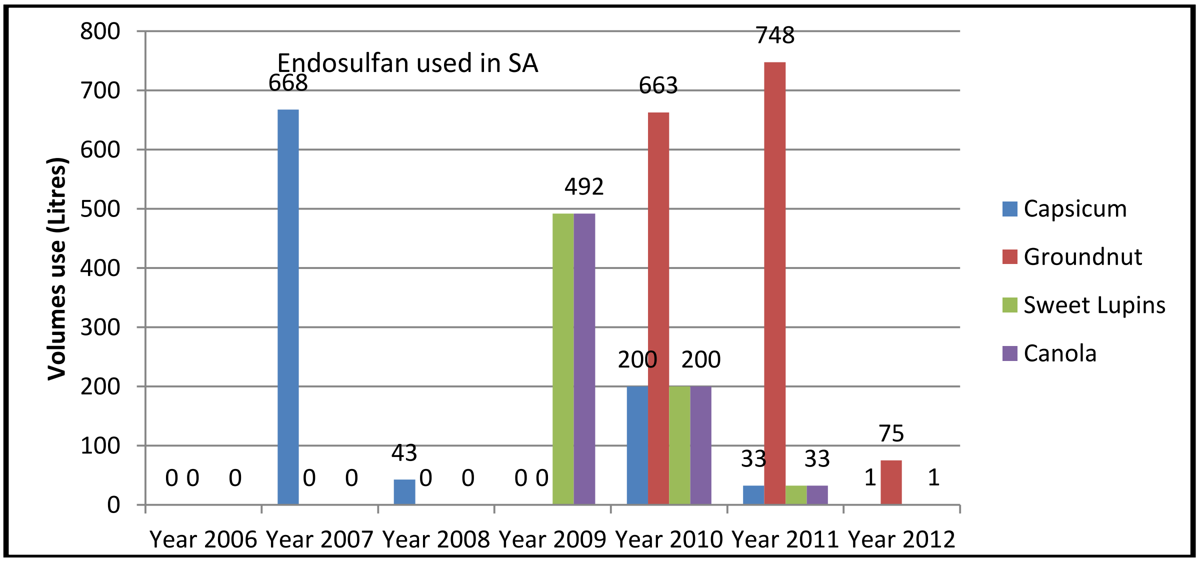

Figure 9.2: Quantities of endosulfan used in to crops such as Capsium, Groundnuts, Sweet Lupins and Canola 2006-20012 in South Africa (Source: AVCASA historical data)

As can be seen in Figure 9.3, the largest quantity (11,157 L) was recorded for sorghum in 2007. This was followed by cotton with 7,431 L in 2006, sorghum (6,809 L) in 2008, cotton (5,894 L) in 2008 and, thereafter, the quantities remained below 5,000 L, with drastic reduction in sorghum and tobacco in 2012.

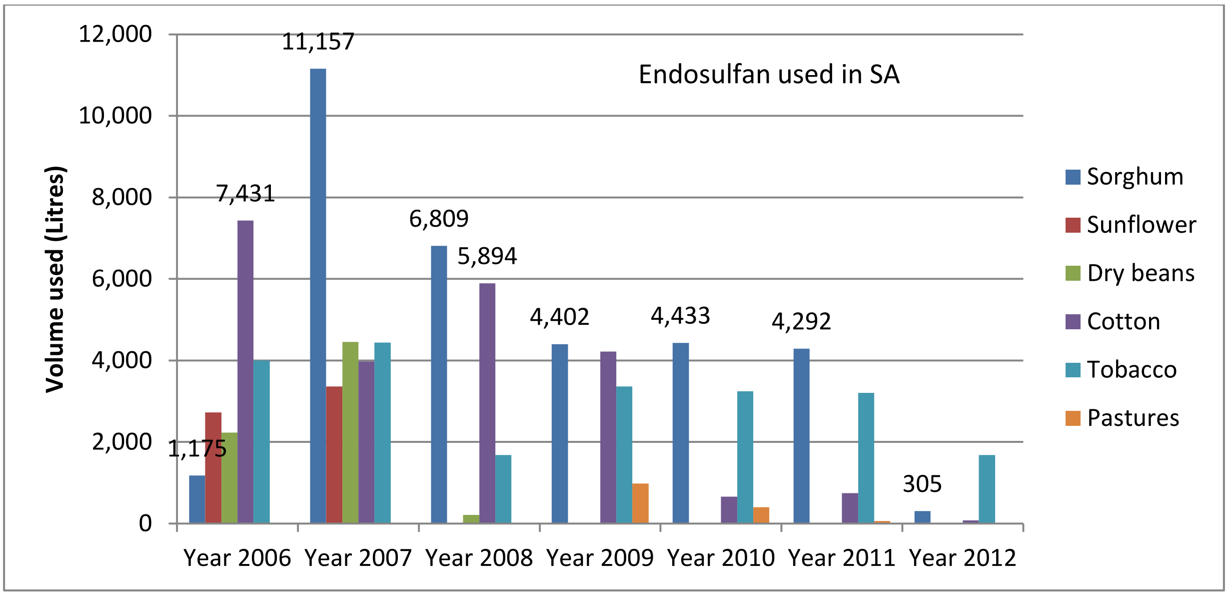

Figure 9.3: Quantities of endosulfan used in sorghum, sunflower, dry beans, tobacco, pastures 2006-20012 in South Africa (Source: AVCASA historical data)

With respect to fruits, there was a gradual increase in the quantities used on pome fruit from 2006-2009 and a drastic increase in 2010 followed by a decrease in 2011, as can be seen in Figure 9.4. The quantities used on other fruits were below20, 000 L, except nuts in 2008 with a record high of 32,013.

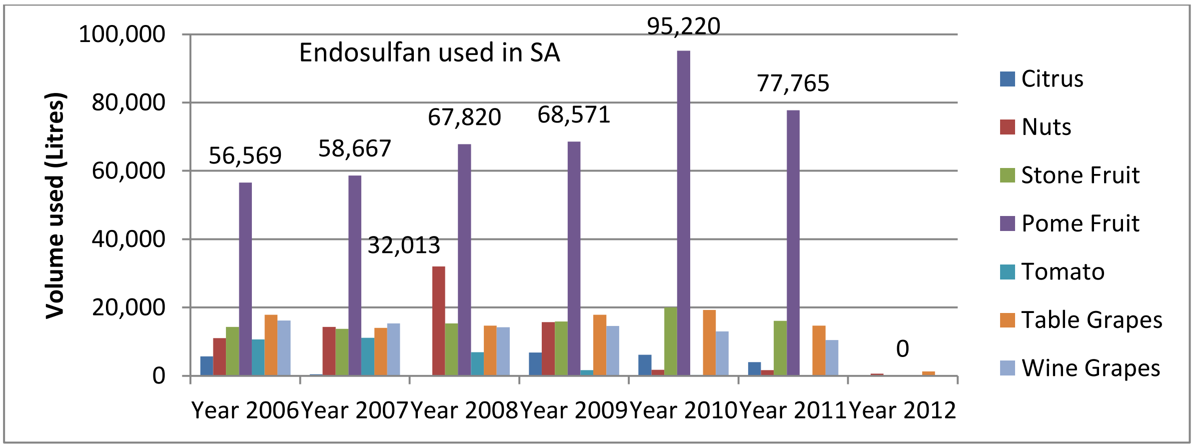

Figure 9.4: Volumes of Endosulfan used in citrus, nuts, stone fruit, pome fruit, tomato, table grapes, wines between 2006 and 20012 (Srce: AVCASA histl. data)

Figure 9.5 shows the quantities of endosufan used on potatoes, brassica, cucurbit, onions and other vegetables. The highest quantity was recorded for brassica in 2007 followed by vegetables in 2008, 2006 and 2009. The highest quantity applied to potatoes was 2, 480 L in

20011. This amount decreased in 2012 to 840 L. For other vegetables, the quantity remained below 20, 000 L.

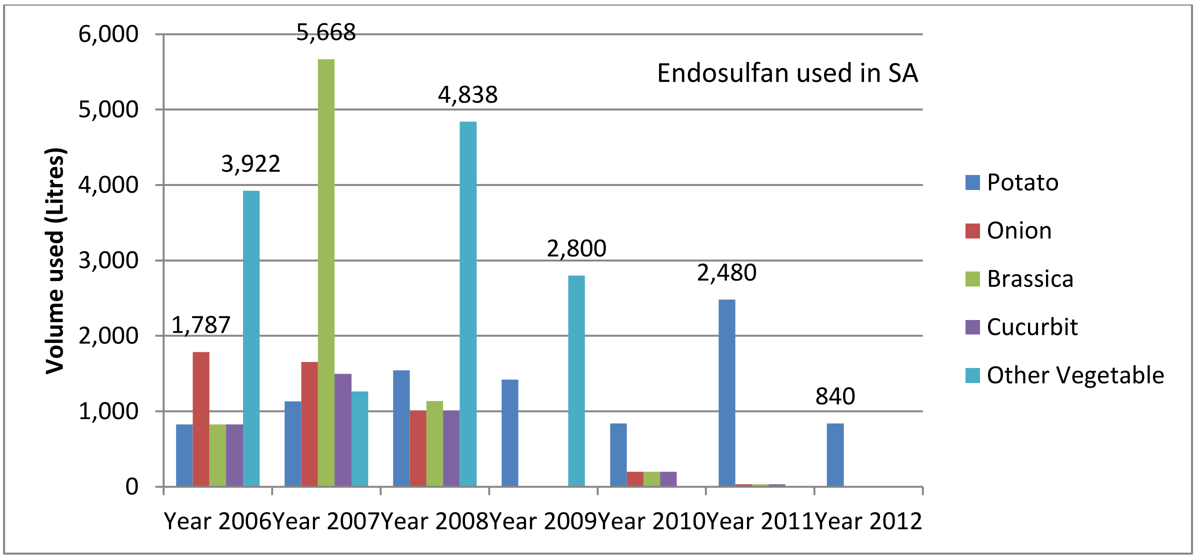

Figure 9.5: Quantities of Endosulfan used in potato, onion, brassica, cucurbit, other vegetables 2006-20012 in South Africa (Source: AVCASA historical data)

Figure 9.6 shows a summary of the total utilization of endosulfan in 2006-2012 in South Africa. The year 2006 accounted for the highest utilization, followed by 2007 and 2008 with 19%, 2009 with 15%, 2010 with 14% and 2012 with 1%.

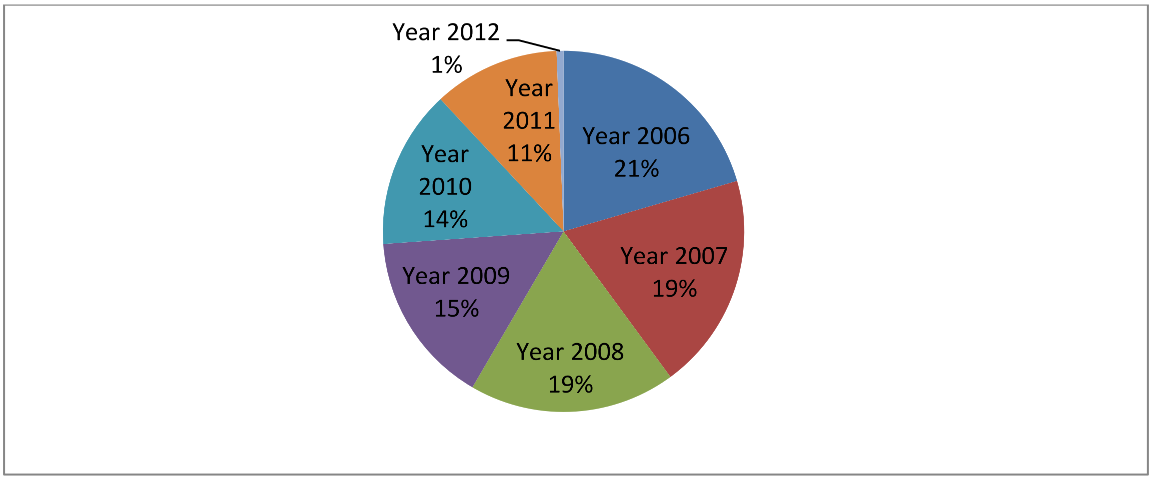

Figure 9.6: Proportion of total utilization of Endosulfan between 2006 and 2012 in South Africa

9.4 Conclusion

The current study was able to show that:

- Large quantities of endosulfan have been used in South Africa, although the quantities have drastically reduced to date;

- The biggest application of endosulfan was on maize.

CHAPTER 10: GAPS

- Information on the applications of PFOS to industrial products was not available;
- Legal document on the banning of some POP chemicals was also not avalable;
- Small scale EEE and WEE recyclers was not accounted in the case of POP-PBDE in EEE casting for polymer;
- Information on contaminated sites is still scanty and, therefore, there is need for more in-depth inventory;
- Specific legislation on POP chemicals was found not to be available, although the Hazardous Chemical Act can suffice for now;
- Monitoring of the use, storage and final disposal of POP chemicals should be intensified;
- Accountability and retention of data on POP chemicals need to be improved;
- Communication and exchange of information on POP chemicals within different Government departments need to improve.

CHAPTER 11: CONCLUSIONS AND RECOMMENDATIONS

11.1 Conclusions

- Quantities of POP-PBDEs in various EEE and WEEE products were determined;
- Σc-OctaBDE in stock, stock entering into the waste stream and polymer fractions (recycling) were calculated;
- The order of Σc-OctaBDE in electronic and electrical equipment were: ICT>refridgerators>PC>TV;
- Σc-OctaBDE and Σc-PentaBDE in imported cars into South Africa from the USA and other regions in 2000-2005 were also determined;
- Analysis of leachate and sediment samples from six landfill sites showed the presence of PBDEs and, therefore, these sites can be confirmed to be contaminated with one of the ten new POP chemicals, PBDEs;
- Large quantities of POP-PBDE are imported into South Africa;
- PFOS accounted for more than 90% of POP chemicals imported into South Africa;
- Verification of data was done by comparing the data obtained from UNcomtrade and **the dti**.
- Of the six pesticides listed, five have been prohibited in South Africa;
- Only pentachlorobenzene and its derivatives appeared not to have been prohibited since no information was available to indicate so;
- Despite the fact that registration of a number of pesticides have been withdrawn years ago, they were still being imported and exported into and from South Africa to date.

11.2 Recommendations

- There was enough evidence to show that a number of the POP chemicals listed under the Stockholm Convention have been used in South Africa to date. There is, therefore, an urgent need to have some regulations to restrict/ban the use of POP chemicals in the country;
- To account for unused POPs chemicals, importers and formulators of these pesticides should give accurate account of the unused chemicals in their possession before renewal of their licenses;
- There is a need to intensify the monitoring of POP chemicals in use and obsolete and their specific applications and

- There are several alternative chemicals to the newly listed POPs chemicals and the use of these alternatives should be encouraged.

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APPENDIX A: REFERENCE DOCUMENTS FOR PROHIBITED PESTICIDES

DEPARTMENT OF AGRICULTURE
Republic of South Africa

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Technical Advice (Act No. 36/1947)
Directorate Agricultural Production Inputs

THIRTY NINTH EDITION - 2002

We gratefully acknowledge Carina J Cilliers, Elizabeth Grobbelaar, R Oberprieler, M Stiller and E Ueckermann of the ARC-PPRI, for providing the slides for the illustrations on the cover

APPENDIX F

WITHDRAWAL AND RESTRICTIONS IN THE USE OF AGRICULTURAL REMEDIES (PESTICIDES) IN THE REPUBLIC OF SOUTH AFRICA

Aldicarb	To be applied by authorised persons ONLY
Aldrin (HHDN)	In1983 the acquisition, alienation, sale or use of aldrin was banned except for the use to protect buildings against subterranean wood destroying termites. In 1992 all uses of aldrin was voluntarily withdrawn
Arsenic	In 1983 all uses of any inorganic arsenic containing compounds on plant material (except on citrus) were banned
Azinphos- ethyl	Withdrawn as an agricultural remedy on 31 March 1997
BHC (mixture of various isomers]	In 1983 the acquisition, alienation, sale or use of BHC was prohibited
Camphechlor	Withdrawn as an agricultural remedy in 1970
Chlordane	As from 31 March 1999 the use of chlordane in agriculture is prohibited. Withdrawn as an agricultural remedy in 2 000
Chlordimeform	Withdrawn as an agricultural remedy in 1978
Chlorobenzilate	Withdrawn as an agricultural remedy in 1978
DDT	Its use as an agricultural remedy was severely restricted in 1970 and in 1971 it was withdrawn as a stock remedy. It was withdrawn from all uses in agriculture in 1976, except for the control of malaria by the Government. The acquisition, alienation, sale or use of DDT was banned in 1983 except for the control of malaria vectors by the government. Severely restricted pesticide (POPs)
Dibromochloropropane	In 1984 was voluntarily withdrawn due to health concern
Dieldrin	All registrations were withdrawn in 1980. The acquisition, alienation, sale or use of dieldrin was prohibited in1983
DNOC	Withdrawn as an agricultural remedy in 2001

Endosulfan	Registration on fodder crops was suspended in 1970
Endrin (Mendrin)	Registration was voluntarily withdrawn in 1980
gamma-BHC	It's use in aerosols and evaporation devices was withdrawn in 1970
Heptachlor	Registration was withdrawn in 1976
Kepone	The use of kepone was prohibited in1971
Leptophos	Registration was suspended in 1980
Mercury compounds	It was withdrawn from all agricultural uses in 1974. In 1983 the use of all mercury compounds on seed, bulbs, tubers, stems or any other plant material was banned
Monocrotophos	In 1989 the use of monocrotophos was voluntarily withdrawn from all agricultural uses in grain crops in the Western Cape. The use of monocrotophos as a leaf application in citrus, for cutworm control in carrots and use on tomatoes were withdrawn as from 31 March 1997
Monofluoroacetic acid (10/80)	Withdrawn as an agricultural remedy in1971
Parathion	All registrations on deciduous fruit and vineyards were withdrawn in 1982. In June 1983 it was withdrawn voluntarily from all uses on beans, coffee, cotton, groundnuts, mangoes, ornamentals, as well as for the control of short-horned grasshopper on various crops
Phosphorus containing formulations	In 1979 all formulations containing phosphorus were withdrawn

228

No. R. 592 **29 May 2009**

FERTILIZERS, FARM FEEDS, AGRICULTURAL REMEDIES AND STOCK REMEDIES ACT, 1947 (ACT NO. 36 OF 1947)

PROHIBITION NOTICE REGARDING THE USE OF CERTAIN AGRICULTURAL REMEDY

I, Lulama Xingwana, Minister of Agriculture, acting under Section 7bis of the Fertilizers, Farm Feeds, Agricultural Remedies and Stock Remedies Act, 1947 (Act No. 36 of 1947) hereby prohibit the use of Agricultural Remedy containing lindane (gamma – BHC) as an active ingredient.

L. Xingwana,
Minister of Agriculture.

GENERAL NOTICES
ALGEMENE KENNISGEWINGS

NOTICE 853 OF 2012

DEPARTMENT OF AGRICULTURE, FORESTRY AND FISHERIES

FERTILIZERS, FARM FEEDS, AGRICULTURAL REMEDIES AND STOCK REMEDIES ACT, 1947 (ACT NO. 36 OF 1947)

PROHIBITION NOTICE REGARDING THE ACQUISITION, DISPOSAL, SALE OR USE OF AGRICULTURAL REMEDY CONTAINING ENDOSULFAN

I, Tina Joemat - Pettersson, Minister of Agriculture, Forestry and Fisheries acting under section 7bis of the Fertilizers, Farm Feeds, Agricultural Remedies and Stock Remedies Act, 1947 (Act No. 36 of 1947) hereby prohibit, as from 01 October 2012, the acquisition, disposal, sale or use of an agricultural remedy containing endosulfan.

Tina Joemat - Pettersson,
Minister of Agriculture, Forestry and Fisheries

AVCASA
ASSOCIATION OF VETERINARY AND CROP ASSOCIATIONS OF SOUTH AFRICA
VERENIGING VAN DIEREGESONDHEIDS- EN PLANTBESKERMINGSVERENIGINGS VAN SUID-AFRIKA
Lanzerac, Constantia Square, Midrand, 1915, HALFWAY HOUSE 1685, SOUTH AFRICA
27 11 805-2000, : 27 11 805-2222, Web : www.avcasa.co.za

MEDIA STATEMENT

CONSUMERS TAKE NOTE: LINDANE IS BANNED

2 February 2010

EMBARGO: IMMEDIATE

STARTS

The Association of Veterinary and Crop Associations of South Africa (AVCASA) discovered that insecticides that contain the active ingredient lindane are still sold in many nurseries and other retail outlets in South Africa despite a national ban on the use of such products. The use of lindane or gamma-BHC as it is also known in the agricultural sector was formally prohibited by the Department of Agriculture, Forestry and Fisheries on 29 May 2009 by Regulation No. 592 under the Fertilizers, Farm Feeds, Agricultural Remedies and Stock Remedies Act, 1947 (Act No. 36 of 1947).

The local banning of lindane follows an international move to add this chemical to the list of Persistent Organic Pollutants (POPs). These chemicals are known to have long term adverse effects on human health and the environment and are characterized by long half-lives due to their chemical structures consisting mainly of carbon, hydrogen and chlorine. Natural break-down assisted by soil microbes, heat and sunlight contribute very little to their decomposition as the molecules are foreign to living organisms.

Traces of lindane can still be found in the soil and agricultural products of the Karoo where it was used extensively more than 25 years ago as a locust insecticide. Last year reports of children being poisoned by lindane-containing hair treatments shocked South Africa and AVCASA questioned the wisdom of still allowing a chemical such as this in human health care products while it was already outlawed for agricultural use. Reports of children being poisoned by lindane used by a pest control operator also highlighted the necessity to ban this POP in South Africa.

Gardeners and home-owners are urged to refrain from buying or using any lindane-containing insecticides even thought such products may still be on sale at certain retailers. Should consumers find such products on the shelves the managers should be alerted to the fact that they are selling banned products. Home-owners should also ensure that pest control operators do not use lindane-containing products on their premises for any purposes. There are new generation insecticides available to responsibly manage garden and home-garden insect pests and there is no reason to purchase or use any lindane-containing products.

For further information please contact:

Mr Tom Mabesa, Executive Director AVCASA at 082-657-5329 or
Dr Gerhard Verdoorn, Griffon Poison Information Centre at 082-446-8946.
ENDS

GN. R. 1061
GG10739
15 May 1987

FERTILIZERS, FARM FEEDS, AGRICULTURAL REMEDIES AND STOCK REMEDIES ACT, 1947 (ACT 36 OF 1947)

PROHIBITION ON THE ACQUISITION, DISPOSAL, SALE AND USE OF CERTAIN AGRICULTURAL REMEDIES AND STOCK REMEDIES

I, Andre Isak van Niekerk, Deputy Minister of Agriculture, acting on behalf of the Minister of Agriculture under section 7bis of the Fertilizers, Farm Feeds, Agricultural Remedies and Stock Remedies Act, 1947 (Act 36 of 1947), hereby prohibit, as from 30 June 1987, the acquisition, disposal, sale or use of-

(1) an agricultural remedy which contains-

(a) chlorobenzilate; and

(2) a stock remedy which contains-

(a) camphechlor; or

(b) gamma-BHC (Lindaan);

Provided that the use of such a stock remedy shall be prohibited from 1 January 1988.

A.I. VAN NIEKERK
Deputy Minister of Agriculture

environmental affairs
Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

Meeting with Mr. ZANEMVULA Miza of SARS on development of National Inventory for ten new persistent organic pesticides (POPs) in South Africa.

Date: 03/04/2013

Venue: LE HAE LA SARS

Time: 11:00am

Signature

signature

environmental affairs

Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

Meeting with ITA PEG / HP ....of................................ on development of National Inventory for ten new persistent organic pesticides (POPs) in South Africa.

Date: 19/04/2013

Venue: Centurion

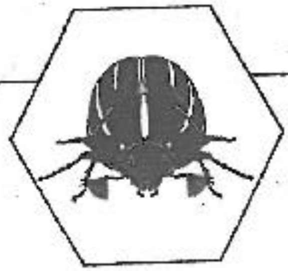
Time: 0930

....

Signature

....

signature



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Dr Gerhard Verdoorn, Griffon Poison Information Centre at 082-446-8946.
ENDS

APPENDIX B: LIST OF STAKEHOLDERS CONTACTED AND ACKNOWLEDGEMNTS

Tables B-1 to B-3 show the list of stakeholders contacted so far to provide information on ten new POPs.

Table B-1: NGOs contacted so far for information on the listed chemicals

CONTACT PERSON	DESIGNATION	ORGANIZATION	MEANS OF COMMUNICATION	RESPONSE
Mr Rico		Groundwork	Email rico@groundwaork.org.za	Sent information via email
Ms L Cokayne	Chief Executive Officer	Griffon Poison Information Centre	Email Lynette Cokayne [info@sapca.org.za	Indicated none availability of information but referred to contact Dr G Verdoorn
Dr G Verdoorn		Griffon Poison Information Centre	Telephone 082 446 8946	Contacted telephonically but referred to the inventory conducted in Gauteng, Limpopo and Western Cape

Table B-2: Private sectors contacted so far for information on the listed chemicals

CONTACT PERSON	DESIGNATION	ORGANIZATION	MEANS OF COMMUNICATION	RESPONSE
Dr M Booth	Director	CAIA	Email Mike Booth[caia2@caia.co.za	Indicated via email on none availability of information
Dr L Lotter		CAIA	Email caia@africa.com	declined meeting
Tim Snow	Chief of field and staff manager	Environmental wildlife Trust	Email snowman@cwt.org.za	Email bounced
Mr M Smit		Savannah Chemicals	Email Michael.smit@savannah.co.za	No response to date
Ms P Pillay		Consumer Goods & Retail Association	Email patricia@cgcsa.co.za	No response to date
Mr R Van Rensburg	Environmental Manager, Africa	Hp (ITASA)	Email Ruben.janse-van-rensburg@hp.com	Meeting held in April and references relevant to the inventory

				provided and has agreed to provide more information on PFOS
Mr D Spence	Executive Director	SA Paint Manufacturing Association	Email deryck@sapma.org.za	Provided information on the application of the pesticides as wood preservatives and hydro-repellent
Dr J Wentzel		Cipla Agricare (Pty) Ltd	Email: info@ciplaagricare.co.za Phone: 021 943 4215	No response to date
Ms Anneke Bignaut,		Polymeric Compounds SA	Email composite@dixade.co.za	No response to date
Mr J Greathead		Aerosol Manufacturers Association	Email mike@aerosol.co.za	No response to date
Mr L Meyer	Sales Director	Mediterranean Textile Mills	Email linsay@mtm.co.za	No response to date
Mr J Merril	Cape Town Agent	Mediterranean Textile Mills	Email	No response to date
Mr Costa Airaga	Operation Director	DESCO Electronic recyclers	Email	To be contacted
Reywin Koekemoer		Bayer CropScience	Email: Reywin.koekemoer@bayercropscience.com Phone 011 365 8675	To be contacted
Rakesh Singh		Dow Agrosciences	Email: RSingh2@dow.com Phone: 032 439 1167	To be contacted
Tammy McDonald		Chemfit Fine Chemicals	Email: TammyM@chemfit.co.za Phone: 011 918 1900	To be contacted
Mr Sipho Mabena		SANS/SABS	Phone: 012 428 6666	Arrangement is being made for a meeting on PFOS in fire-fighting clothes

Table B-3: Government departments contacted for information on the listed chemicals

CONTACT PERSON	DESIGNATION	GOVERNMENT DEPARTMENT	MEANS OF COMMUNICATION	RESPONSE
Mr R Loyisoonial	Deputy Director	Department of Health, Pretoria	Email Loykir@health.gov.za	No response so far despite reminders
Mr M Ramathuba	Deputy Director	Department of Health, Pretoria	Email Bongwf@health.gov.za	No response so far despite reminders
Mr J Mudzunga	Registrar	Department of Agriculture, Forestry & Fisheries, Pretoria	Email and telephone malutam@daff.gov.za	Meeting held in March and has agreed to provide contact details of pesticide importers & formulators
Mr T Mabesa	Executive Director	AVCASA	Email and telephone tom@avcasa.co.za	Has shown no interest for a meeting but referred to the ***National Retrieval Scheme*** and indicated that DEA should have a copy
Ms R Ramdhani	Deputy Director, chemicals	dti	Email rramdhani@thedti.gov.za	Has agreed for a meeting once she is back from sick leave in May
Mr Z Miza	Assistant Director	SARS	Telephone 012 422 4451	Meeting held in April and has agreed to supply data on POPs import/expor
Ms K Olifant	Assistant Director	Statistics SA	Telephone	Telephonically indicated that no statistics on POPs
Ms L Nemavhadwa		Gauteng Department of Transport	Telephone 073 254 2341	Meeting held in March and has agreed to supply information on the number of vehicles imported into SA
Mr D Buthelezi	Deputy Director	dti	Email DButhelezi@thedti.gov.za	Referred to Ms Reshika Ramdhani for assistance
Mr D Hadabe		dti	e-mail: Dhadabe@thedti.gov.za	
Ms Flavia Masekwaneng		DoH		
Ms Vuyokazi Mpumlwana		DeaAR gvt store		

Table B-4 (ACKNOWLEDGEMENTS)

REFERENCE GROUP	AFFILIATION
Mr Obed Baloyi, Chief Director, Chief Directorate: Chemicals Management	Deprtment of Environmental Affairs
Ms M Moloi, Deputy Director, Chief Directorate: Chemicals Management	Deprtment of Environmental Affairs
Mr G Khauoe, Assistant Director, Chief Directorate: Chemicals Management	Deprtment of Environmental Affairs
Mr. Tom Mabesa, Executive Director	Agricultural and Veteinerary Council of South Africa
Mr R Euripidou	GroundWork
Ms Vuyokazi	Government Store, DeAar, Northern Cape
Mr Costa Airaga, Operations Director	Desco Electronic Recyclers
Mr M Whitehouse, Sales and Marketing Manager	Desco Electronic Recyclers
Mr Ruben Van Rensburg, Environmental Manager	Information Technology Association of South Africa
Mr. Hadebe, Director	**the dti**
Mr D Buthelezi, Deputy Director	**the dti**
Ms F Masekwaneg, Deputy Director,	Department of Health