National Implementation Plan for the Stockholm Convention on Persistent Organic Pollutants:

A Report on Newly Listed Industrial POPs in Kenya

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March 2014

Executive Summary

The Stockholm Convention is a global treaty to protect human health and the environment from Persistent Organic Pollutants (POPs). The Convention requires that Parties adopt and introduce measures to reduce releases of POPs into the environment with the aim of reducing human and wildlife exposure. Parties to the Stockholm Convention of which Kenya is a member are required to develop a National implementation plans (NIPs) for persistent organic pollutants and to review and update their NIPs, as appropriate, periodically and to address new obligations under the Convention. Kenya developed its NIP in the year 2008. This year (2013) Kenya has embarked on reviewing and updating its existing NIP. In the year 2009, new POPs were added to the previous list of POPs and among them are the Polybrominated diphenyl ethers (PBDEs) and Hexabromobyphenyl (HBB) which were listed in Annex A for eradication. Perfluorooctanoic sulfonate (PFOS) and related substances, listed in annex B for restricted use. PBDEs, HBB and PFOS are collectively known as industrial POPs. These chemicals have the potential to be transported long distances and deposited far away from their place of release including in pristine environments such as the Arctic. There are 22 POP chemicals listed in the Convention. The pesticides and industrial chemicals listed in the Convention have been banned in the many countries, with some limited exemptions.

The Kenyan NIP in 2008 did not include newly listed industrial POPs. This report is an assessment of industrial POPs in Kenya with the aim of updating the Kenyan NIP. It can be observed that the greatest challenge in Kenya concerning its mandatory obligation to Stockholm convention is lack of awareness by key stockholders on industrial POPs. Majority stakeholders cannot identify the industrial POPs by their chemical names. The consequence of luck of awareness by stakeholders has resulted in imports of these chemicals, unregulated cross border movements of products containing industrial POPs. The current estimates of industrial POPs in products and what is being generated annually in Kenya is 677.2 Kg from Motor vehicles, 211.7 kg from CRTs, 520.9 kg from TVs, 780.1 kg from Computers for POP-PBDE. For PFOS and related substances, 9200 Kg of AFFF and fluoroprotein are released every year in the environment through firefighting processes and training fire personnel. The release of Industrial POPs to the Kenyan environment is through poor waste disposal methods and storage. Poor disposal and storage methods expose both POP-PBDEs and PFOS and related substances to the environment and ultimately a risk to human.

Incorporating the industrial POPs in the NIP is a good progress and in terms of future activities, the priority is to gain a better understanding of the potential scale and level of emissions from past uses and in-use items containing industrial POPs, particularly when they enter the waste stream.

This report has been divided into 5 sections chapters. The background information on the project and report is provided in section 1. Section 2 gives literature on historical use of industrial POPs and human exposure. Section 3 presents the work plan for inventory for industrial chemicals and how the data and information was obtained. In the same section, there is a list of industries and organizations where the information was obtained. Section 4 is the assessment and quantification of industrial POPs in Kenya in different products, releases to the environment and stockpiles. Import and export data is also provided in this section. Section 5 is about the implementation action on Industrial POPs, guidance on BAT and BEP for the use of PFOS and related chemicals, POPs PBDE and HBB. Alternatives to these industrial POPs are outlined in section 5. The same section provides information on monitoring of industrial POPs in Kenya. Descriptions of the industrial POPs are in Annex 2 while glossary of terms and units used Annex 1. Conclusions are in Section six, of which recommendation and Action Plan, Legal and Policy issues to be addressed are provided.

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Section 1

1.0 Introduction

The term industrial POPs is a generic term for Persistent Organic Pollutants that are generated mainly through industrial processes or chemicals that are used as additives in various industrial products for specific purposes. These chemicals are brominated compounds that are used mainly as flame retardants and Per-fluorinated alkyl chain compounds that are used for various purposes such as surfactant. In Kenya, the major source of PFOS are firefighting foams while for PBDEs is motor vehicles and electronics.

1.1 Newly Listed Industrial Persistent Organic Pollutants

Industrial POPs are chemicals that are produced for industrial purposes. In May 2009, the Conference of the Parties that are signatory to the Stockholm Convention adopted amendments to Annexes A, B and C of the Stockholm Convention to list nine new persistent organic pollutants (POPs). Among the nine POPs are the industrial POPs which include mainly fluorinated and brominated compounds. These Industrial chemicals include: hexabromobiphenyl, hexabromodiphenyl ether and heptabromodiphenyl ether, perfluorooctane sulfonic acid, its salts and perfluorooctane sulfonyl fluoride, tetrabromodiphenyl ether and pentabromodiphenyl ether. Industrial POPs are toxic and persist in the environment. They bio accumulate in fatty tissues of organisms, biomagnify through the food chain and exhibit long range transportation. Descriptions of each of the industrial POPs are provided as follows.

1.1.1 Perfluorooctane sulfonate and perfluorooctane sulfonyl fluoride

Perfluorooctane sulfonate (PFOS) and related substance Perfluorooctane sulfonyl fluoride (PFOS-F) are Annex B substances.

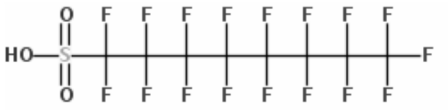

Figure 1-1-1: Perfluorinated sulfonate (PFOS; $C_8F_{17}SO_3H$)

The characteristics of Perfluoroalkylated compounds that cause them to persist in the environment are also the characteristics that made them attractive compounds for industrial

usage for over 50 years. PFOS is both intentionally produced and an unintended degradation product of related anthropogenic chemicals. PFOS was manufactured by the 3M Company in Europe as a surfactant for a range of applications until 2001. It is understood that some small scale manufacture of PFOS might have continued outside Europe after 3M ceased production. Perfluorinated compounds in general are regarded as PBT (persistent, bioaccumulative, and toxic) chemicals and cause diverse toxic effects in laboratory animals including primates (Biegel et al., 2001 and Butebhoff et al., 2002). Concern about their presence in the environmental increased since PFOS and related fluoroalkyl substances were detected in blood plasma of nonoccupationally exposed humans and in animal tissues collected from around the globe.

1.1.2 Polybrominated Diphenyl Ethers (PBDEs)

The four POPs in the category of Polybrominated diphenyl ether (tetra, penta, hexa and hepta BDE) are substances which have either been used as flame retardants or been present in commercial grade flame retardant products.

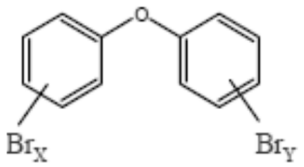

Figure 1-1-2: Poly brominated diphenyl ethers (PBDEs). Penta-BDE (average 5 bromines), Octa-BDE (average 8 bromines), Deca-BDE (average 10, fully brominated)

They are Annex A substances, and have been banned for production. However, due to their historical use they are still present in the products that were manufactured before the ban. In 2005 Norway nominated the brominated flame retardant commercial pentabromodiphenylether (c-PentaBDE) as a persistant organic pollutant (POP) to be evaluated for inclusion in the Stockholm Convention. Based on its Risk Profile developed in 2006 and its Risk Management Evaluation Report developed in 2007. Emissions of tetra and pentaBDE from in-use items and in waste streams are estimated to be more significant than those arising from past manufacturing or use. This is because PUR foams, carpets, textiles, furnishings and other items which may have been treated with pentaBDE prior to the 2003 ban remain in use and will continue to enter waste streams for some time. 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 compilation of PBDE production data 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 (see table 1-1).

Table 1-1: 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

1.1.3 Hexabromobiphenyl

Hexabromobiphenyl (HBB) was used as a flame retardant within a number of plastic applications, mainly in the 1970s and was shortly banned in 1977. Plastic products treated with HBB are expected to have a lifespan ranging from five to ten years. It is therefore unlikely that there have been any significant HBB emissions to the environment after 1990. Presently, it is believed that the presence of HBB especially in regions far away from where production took place is insignificant.

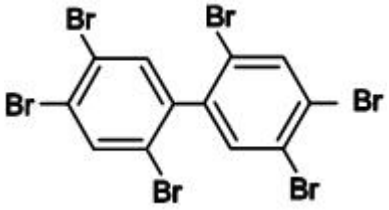

Figure 1-1-3: Hexabromobiphenyl. Additive Flame Retardant used in thermoplastics, PS padding, calbe, latex, textiles

1.2 Kenya country baseline and profile

Unlike the developed economy countries, Kenya does not manufacture the industrial POPs. Most of the industrial POPs enter Kenya through the importation of finished consumer products. Some of the goods include electronics, vehicles, firefighting foams, and textiles among others. Therefore Kenya with a population of over 40 million people is mostly a consumer country. Being a third world economy, the technical capacity of Kenya is low, and therefore the technical and institutional capacity to address the problem of POPs is very limited. However there is political will to implement the requirements of the Stockholm convention and other treaties concerning proper use and management of POPs such as Basel and Rotterdam conventions. The Convention recognizes the particular needs of developing countries and specific provisions on technical assistance and financial resources and mechanisms are included in the general obligations.

1.3 Purpose of the Kenyan National Implementation Plan and the Development of the updated Kenyan National Implementation Plan for Industrial POPs

Kenya is a signatory to the Stockholm Convention treaty on Persistent Organic Pollutants (POPs) which was entered into force in May 2004. Kenya implemented its treaty obligations and produced its National Implementation Plan (NIP) for POPs. However in the NIP, industrial chemicals (such as penta-bromodiphenyl ether and perfluorooctane sulfonate and related substances) were by then not in the initial list of POPs. Addition of these new POPs (in 2009) required that members' states update and revise their NIP to include industrial POPs and other new POPs. The Kenyan NIP is subject to periodic updating and revision in response to the dynamic nature of the Convention, for example, in its identification and inclusion of additional POPs.

1.4 Objectives

To revise and update the Kenyan NIP by incorporating the Industrial POPs in addition to the POPs that were covered in 2008. This will provide a framework for the development of regulations and policies for the NIP in Kenya.

1.4.1 Specific objectives

- To produce an inventory for Industrial POPs in Kenya
- To estimate the releases of PBDE and PFOS and related substances per annum in Kenya
- To provide guidance and awareness on sustainable management of Industrial POPs in Kenya.

Section 2

2.1 Historical use and release pathways of industrial POPs

2.1.1 Hexabromobiphenyl (HBB)

Hexabromobiphenyl (HBB) was used as a flame retardant within a number of plastic applications, mainly in the 1970s. Emissions to air, land and water would therefore have occurred throughout the lifecycle of the product including after final disposal to landfill. Plastic products treated with HBB are expected to have a lifespan ranging from five to ten years. It is therefore unlikely that there have been any significant HBB emissions to the environment after 1990. It is therefore unlikely that there have been any significant HBB emissions to the environment after 2008, the year the Kenyan NIP was drafted. Emissions to air, land and water would therefore have occurred throughout the lifecycle of the product including after final disposal to landfill.

HBB was used as a flame retardant in three main commercial products (Neufeld et al., 1977; IPCS, 1994; ATSDR, 2004):

- ABS (Acrylonitrile Butadiene Styrene) thermoplastics (plastic for constructing business machine housings and in industrial (e.g. motor housing) and electrical (e. g. radio and TV parts) sectors);
- PUR (Polyurethane) foam for automotive upholstery;
- Coatings and lacquers;

2.1.2 Polybrominated diphenyl ether (tetra, penta, hexa and hepta BDE)

The four POPs in this category are substances which have either been used as flame retardants or been present in commercial grade flame retardant products. Tetra and pentaBDE are the two main polyBDE congeners found within commercial pentaBDE. The hexaBDE congener may also be found in low concentrations in commercial pentaBDE. Hexa and heptaBDE are congeners found within commercial octaBDE. This is because carpets, textiles, furnishings and other items which may have been treated with pentaBDE prior to the 2003 ban remain in use and will continue to enter waste streams for some time. It is estimated that tetra and pentaBDE may be emitted to air, land and water during use and following disposal of these goods. Polybrominated diphenyl ether (tetra, penta, hexa and hepta BDE). Tetra and pentaBDE are the

two main polyBDE congeners found within commercial pentaBDE. The hexaBDE congener may also be found in low concentrations in commercial pentaBDE. Hexa and heptaBDE are congeners found within commercial octaBDE. Historically commercial octaBDE had more limited applications than pentaBDE, as it was primarily used as an additive flame retardant in plastic housings for electrical goods. Commercial pentaBDE was used as an additive flame retardant in a number of plastic applications, as well as being widely used in soft furnishings. Although both commercial penta and octaBDE have been banned in many developed countries, low levels of brominated chemicals could continue to be present in unlabeled recycled plastics.

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;
- Recycling industry;

2.1.2.1 Historical use in Kenya

In Kenya, PBDEs was used in different resins, polymers, and substrates at levels ranging from 5 to 30 % by weight. The quantities used for each specific application are not publicly available available. However, estimates can be calculated as indicated in section 3. Table 2-1 shows the use of c-PentaBDE in various materials and applications. The use and application of PBDEs in products in Kenya is heavily dependent on import materials. This is because PBDEs are not manufactured in Kenya. Therefore the history of production in producing countries where Kenya imports these materials or products is important in order to provide estimates of the amounts of PBDEs in circulation in Kenya. Example, the origin country of import of motor vehicles, their category will vary among global regions of manufacture mainly, Central America, Europe and Asia. Some toxicological effects associated with PBDEs include: neurodevelopmental effects, Neurobehavioral effects, cancer, thyroid problems, neurodevelopmental.

Table 2-1 use and Application of c-PentaBDE in various materials and applications in Kenya

Materials/polymers/resins	Applications	Commercial commodities for the applications	Main Kenyan Companies/Institutions
Epoxy resins	Circuit boards, protective coatings	Computers, ship interiors, electronic parts.	Cables and Electronic Companies
Polyvinylchloride (PVC)	Cable sheets	Wires, cables, floor mats, industrial sheets.	Cables and Electronic Companies
Polyurethane (PUR)	Cushioning materials, packaging, padding	Furniture, sound insulation packaging, padding panels, wood imitations, transportation.	Mattresses manufacturers
Unsaturated (Thermosetting) polyesters	Circuit boards, coatings	Electrical equipment, coatings for chemical processing plants mouldings, military and marine applications: construction panels.	Electronics importers
Rubber	Transportation	Conveyor belts, foamed pipes for insulation.	Cable companies
Paints/lacquers	Coatings	Marine and industry lacquers for protection of containers	Paint and Ink Companies

Another example is in the imports of polyurethane foam whose ingredients Kenya has been importing for the production of cushioning and other uses. There is no data available on the proportions of use of c-PentaBDE for the different applications in in the US. Based on the latest available information from Bromine Science and Environmental Forum (BSEF), the total market demand of c-PentaBDE has decreased from 8,500 tons in 1999 to 7,500 tons in 2001. C-PentaBDE has been produced in Israel, Japan, US and the EU. China may have produced for their market as well. Since 2004 c-PentaBDE is no longer produced by at least BSEF member companies (BSEF, 2009). Today there is no production in Japan and c-PentaBDE was voluntarily withdrawn from the Japanese market in 1990 (UNECE 2007).

2.1.3 Perfluorooctane sulfonic acid (PFOS)

Perfluorooctane sulfonic acid (PFOS) was banned under the terms of the controls on dangerous substances and Preparations Regulations 2007. However there are exemptions for its use in the

chrome plating, semi-conductor and photographic industries. Exemptions for PFOS under the EU POPs Regulation are as follows:

(a) until 26 August 2015, wetting agents for use in controlled electroplating systems;

(b) photoresists or anti-reflective coatings for photolithography processes;

(c) photographic coatings applied to films, papers, or printing plates;

(d) mist suppressants for non- decorative hard chromium (VI) plating in closed loop systems;

(e) hydraulic fluids for aviation.

Health effects of acute exposure to PFOS include; dermal irritation, effects on the liver (liver enlargement), gastrointestinal and thyroid hormone effects, hepatotoxicity effect and suggested carcinogenicity in a small number of occupational studies and animals studies.

PFOS and related substances are used in the following industries among others: Synthetic carpets

- Paper and packaging
- Industrial and household surfactants
- Coating, paint and varnishes
- Fire-fighting foams
- Aviation hydraulic fluids
- Insecticides
- Metal plating industry/chrome plating

2.2 Human exposure to industrial POPs

Trudel et al. (2008) reported that oral ingestion of contaminated foodstuffs and drinking water accounts for the largest proportion of Per-fluorinated compounds (of which PFOS and related chemicals belong to) exposures for adults. Tittlemier et al. (2007) and Haug et al. (2011) also expressed the opinion that water and foodstuffs are the most important uptake path. Recently the account for body burdens found for many new POPs and indoor exposure from air and dust has been hypothesized as also important (Björklund et al 2009, Björklund et al 2011 and Thuresson at al 2011). The major source of industrial POPs especially PBDEs is the end of life products mainly motor vehicles, electronic products and household goods.

Section 3

3.0 Work Plan for Inventory for Industrial POPs in Kenya

This Section gives the strategy and plan that was used for making the inventory of the industrial POPs in Kenya. The inventory is geared towards revising and updating the Kenyan NIP. Due to the complexity nature of POP-PBDE inventories, the methodology that was adopted to collect data was the tiered approach, as explained in the POP-PBDE inventory guidance (Secretariat of the Stockholm Convention, 2012). The approach involves (i) Initial assessment of the general situation which involves desk study, (ii) preliminary inventory" which involves site visits, desk research, and surveys to further estimate the national data that were identified as missing information in the initial assessment and finally (iii) in-depth inventory which include site inspections and physical laboratory analysis of collected samples to verify and obtain levels of the POPs in various environmental matrices. The same methodology was used for PFOS and related substances (PFOS Inventory Guidance, 2012).

Questioners were used to get information and data for various sectors and their stakeholders. The format of the various questioners was based on those in the Inventory Guidance (Secretariat of the Stockholm Convention, 2012) with slight modifications.

3.1 Data acquisition for industrial POP PBDEs

Information required for the inventory of products that contain PBDEs included the imports and exports data, and information of the source countries. Questioners were used to obtain data and information from various sectors and their stakeholders. The following sectors were categorized and their data obtained,

a) Transport sector
    - Buses
    - Trucks
    - Cars
    - Motor cycles

b) Electronics
    - Monitors; Cathode ray tubes (CRT) and Liquid crystal display (LCD)
    - Computers; Desktop (inclusive of keyboards and mouse) and Laptops
    - Printers/photocopiers
    - Mobile phones
c) Radios
d) Refrigerators
e) Television; Cathode ray tubes (CRT) and Liquid crystal display (LCD)
f) Electric cables
g) Furniture, mattresses' and textiles
h) Contaminated cites

Key industries and government institutions were identified as the source of data and information regarding the categorized sectors. Table 2-1 shows the industries and government institutions that were selected as major data and information source.

Table 3-1: Industries and government institutions showing the sectors and products where data was obtained for POP PBDEs.

Sectors/category	Product	Industry or institution
Transport	Buses, Trucks, Cars, Motorcycles	Kenya bureau of statistics (K.N.B.S), Customs, CMC, KVM, GM, Toyota Kenya
Electronics	Computers/Printers/Copiers Mobile phones Radio Refrigerators Electric cables	Customs, K.N.B.S, HP office, Dell office, Acer office etc Customs, Nokia Kenya, sum sang, Sonny etc Customs (K.N.B.S), Customs (K.N.B.S), East African cables
Furniture, mattresses & textiles Contaminated sites &		Vitafoam ms, Bobmil, Superfoam ltd, silent night Dandora, East African Compliant recycling,
Recyclers		Mombasa, (WEEE) Mombasa road, Computers for schools Kenya

In addition, selected places were visited (site seeing) which include and not limited to the following places

a. East African Compliant recycling, Mombasa & Port-Customs
b. Kenya national bureau of statistics (K.N.B.S)
c. East African cables

3.1.1 Quantification of POP-PBDE in various product categories.

The quantification of POP-PBDE in various product categories followed the methods in the Guidance for the inventory of polybrominated diphenyl ethers (PBDEs) listed under the Stockholm Convention on Persistent Organic Pollutants, July 2012. Calculations for various PBDE quantities are shown in Annexes 2.6 to 2.10.

Inventory and quantification was made for the following,

- Inventory of POP-PBDEs in electrical and electronic equipment (EEE) and related waste (WEEE)
- POP-PBDEs in imported and exported EEE
- POP-PBDEs in stocks of EEE
- POP-PBDEs in EEE entering the waste stream
- POP-PBDEs stockpiles

3.2 Data acquisition for PFOS and related substances

Information required for the inventory of products that contain PFOS was acquired. This information included the imports and exports data, and information of the source countries. Questioners were used for various sectors and their stakeholders. The following sectors were categorized and data on production or usage of industrial POPs obtained,

- Paper and packaging
- Fire-fighting foams
- Aviation hydraulic fluids
- Synthetic carpets
- Industrial and household surfactants
- Coating, paint and varnishes
- Municipal dump sites.
- Insecticides
- Metal plating industry
- Metal plating in closed loop-system

- Hard metal plating
- Decorative metal plating

Key industries and government institutions were identified as the source of data and information regarding the categorized sectors. Table 2-2 shows the industries and government institutions that were selected as major data and information source.

Table 3-2: Industries and Government institutions showing the sectors and products where data was obtained for PFOS and related chemicals

Sectors	Industries and institutions
Synthetic carpets	Kenya National Bureau of Statistics (K.N.B.S), Customs, plastic carpets manufacturers
Paper and packaging	Customs, KBS, Chandaria
Industrial and household surfactants	Customs, Unilever
Coating, paint and varnishes	Crown and Galaxy paints
Fire-fighting foams	Customs & Municipal fire fighters, Local government ministry, Securex, G4S,
Aviation hydraulic fluids	Kenya airports Authority, Jomo Kenyatta International Airport
Insecticides	Orbit, Tiger chemicals, PCPB
Metal plating industry/chrome plating	Steel rolling
Dumpsites & stockpiles	Fire fighters, Dandora

The places that were visited (site seeing) included and not limited to the following places

a. JKIA
b. Kenya National Bureau of Statistics (K.N.B.S)
c. Plastic Carpets Manufacturers
d. Sampling at Dandora and Sabaki And Tana River

3.2.1 Quantification of PFOS and its related substances in various product categories.

Statistics on import, manufacture and export were obtained annual net consumption of PFOS and its related substances were estimated. To quantify the amounts of PFOS in all use categories, data was processed based on statistical data on manufacture, export and import volumes from K.N.B.S and the K.R.A. Data on stockpiles in various industries and institutions were obtained through questioners. Estimation and calculation of various amounts followed the Inventory Guidance of 2012. Calculations for various PFOS and related substances quantities are shown in Annexes 2.1 to 2.5.

Inventory and quantification was made for the following,

- Inventory of firefighting foams, aviation hydraulic fluids and insecticides containing PFOS and its related substances
- Estimation of produced and used PFOS and its related substances in the industrial sector
- Inventory of articles and products containing PFOS and its related substances on the consumer market
- Screening of environmental samples to verify the presence of PFOS and its related substances
- Inventory of waste, stockpiles and contaminated sites containing PFOS and its related substances.

Section 4

4.0 Assessment of Industrial POPs in Kenya

The estimated quantities results on current releases of the industrial POPs to the environment, import and export statistics for concerned products and resultants of studies done in Kenya for PFOS are provided and discussed in this section. Kenya does not manufacture any of the banned flame retardants (PBDEs) and also any of the PFOS and related substances. However this study reports that products containing PBDEs are still in circulation in Kenya through continual imports for use in various industries. Recycled products such as vehicles and imported electronic goods such as computers for reuse being the main sources of the PBDEs. Without strict regulation, this can be termed as the "dumping" of such products from others countries. PBDEs containing raw materials mainly polymers may also be a significant source i.e in mattress, foam and plastic manufacturing industries in Kenya.

The leading source of PFOS and related substances is the imports of AFFF used for firefighting. A significant amount may also be through imports and use of domestic appliances in Kenya as observed through environmental matrices (sediments, water and even fish) analyzed for PFOS. The following table shows the main information observation from selected companies and institutions visited

Table 4-1. Main information observation from selected companies and institutions visited

Company / institution	Information sort	Questionnaire	Site Visit	Main observation	Contact person
Nairobi City council fire fighters	Fire-fighting form	✓	✓	Open storage facility at industrial area Training using AFFF foam Noted that a lot of a stock at the facilities	Mr. Jacktone Mbuya Assistant Chief officer, tel: 0722846896 Mr. Sammy Kimayoro Fire trainer Tel: 0722458443
KRA Nairobi	Import and export data		✓	Data obtained was mostly from 2005	Commissioner of customs, Mr. Yego. Tel: 020 281-7142/1
K.N.B.S	Import and export data		✓	Data obtained was mostly from 2005	Director general Box 30266-00100 NAIROBI
KVM Thika	Vehicle manufacture data	✓	✓	No much release of PBDEs from the processes	Mr. Otieno
JKIA	Aviation hydraulic fluids	✓		Restrictions to visit. Need to be advised on proper storage and disposal in case of stockpile of expired fluids	Director general,KNBS P.O.Box 30266 -00100 Nairobi
Wilson airport	Aviation hydraulic fluids	✓	✓	Restrictions to visit. Need to be advised on proper storage and disposal in case of stockpile of expired fluids	Commission of customs & Mr. Mabunde
East African cables	PBDE, Polyvinylchloride (PVC)	✓		Lack of awareness. They have little waste generated at the site	Product manager. Addis Ababa Rd, Industrial Area P.O. Box 18243 - , Nairobi, Kenya. Nairobi 00500 Kenya
Dandora Dump site	All solid waste dump site		✓	Needs clearing the site. Mixed waste that contains POPs	N/A
Ngara electronic waste handlers	Mixed electronic waste. Potential PBDE exposure		✓	Advised to send the waste to Athi river. Poor storage (The storage should be in an enclosed area).	N/A
Computer for Schools (CFS) recycling center, Nairobi	-Refurbishing computers from donors to give to schools (WEEE)	✓	✓	Alternative proper E-waste disposal through recycling. Uncontrolled imports of the out of use computers	National Youth Service - Ruaraka P.O. Box 48584-00100, Nairobi, Kenya. Tel: +254 (0) 20 2060921, Tel/Fax: + 254 (0) 20 2060920
East African Compliant recycling Athi river	E-waste that contain PBDE disposal systems and quantities involved	✓	✓	Best practice in E-waste handling and disposal.	Contact Mr. Robert, 0728655342
Vitafoam	PBDE, Polyurethane foam (PUR). Polyol additive	✓	✓	No burning on site. Recycling.	Clement Pushparaj Production manager. Tel 0722-205535
Bobmil Industries	PBDE, Polyurethane foam	✓	✓	Some burning observed. Recycling	Bobmil Complex, Mombasa Road

Limited	(PUR). Polyol additive				P. O. Box 48876-00100, Nairobi, Kenya Tel: +254-020-2032120/1
G4S Nairobi	Firefighting foams (PFOS and related substances	✓	✓	Storage facilities need to improve. A cooler environment for storage is required	Faustin Kithaka Fire services Operations. 0722973543
Private Incinerator, Kitengela	All hazardous waste incineration	✓	✓	Poor storage before incineration. Located in public settlement is not advisable	Dr. Dr. Philip Ogwari
Oserian Flowers	Solid and Hospital waste		✓	Inefficient incinerator on site.	Environment and safety manager. P.O Box 2010, Naivasha, 20117, Kenya +254 (0) 50 2030210 / 2021036 +254 (0) 727 534 55
Nakuru District Hospital	Hazardous Hospital waste & incineration		✓	Good waste management. Functional incinerator but with low loading capacity.	
Nakuru District Hospital, Blood center	Expired blood stockpile incineration		✓	Good waste management. With a functioning incinerator. However, poor storage of waste at the incinerator facility (open storage)	
Kenya seed Nakuru	PFOS in pesticide formulations		✓	N/A. no evidence of PFOS formulation in the pestcides	
Nakuru Municipal Dump site	All solid waste dump site		✓	Needs clearing the site. Mixed waste that contains POPs	
Bata Shoe Company Limuru	Perfluorinated compounds in Leather treatment		✓	Lack of awareness. Minimal but both PBDEs and PFOS and related chemicals are circulated in the process	Peter Giathi. 0722362386
Orbit chemicals		✓		Still waiting for questionnaire return. Minimal use of newly listed industrial POPs	Ms. Opaki
Crown Paints		✓		Still waiting for questionnaire return. Minimal use of newly listed industrial POPs	Factory manager
General Motors	PBDE in foam	✓		They require incineration facilities. Minimal waste at the facility	
Customs Mombasa	General information & clearance processes		✓	Policy covers the whole of East Africa. Chemical not tested at port entry, but send to Mombasa. -Information on restricted & banned chemicals, however, not updated. Wrong chemical names in the information booklet. - counterfeits problems -require training -update of concerned POPs	Mrs. Tabitha Mwangi
Mabati Rolling industries			✓	Minimal application in the coolant application process (as a surfactant)	Mr. Kiprono Mr. Peter Njuguna

Bamburi cement	Private incineration. Electronic waste storage		✓	- Open waste storage at site before incineration. - Fumes emission, but may not contain newly listed industrial POPs	Mr. Geraed Kokach Environment officer
KPA and KPC Mombasa	Solid waste & Firefighting station	✓		KPA has its own firefighting facility at the site	
Kwale International Sugar Co.	Solid waste disposal		✓	Not yet in operation at the time of visit	Harmish Barkley Agricultural Estate administration
G4S Mombasa				They don't store firefighting foams	
Computer for Schools (CFS) recycling center, kakamega	-refurbishing computers from donors to give to schools (WEEE)	✓		Alternative proper E-waste disposal through recycling. Uncontrolled imports of the out of use computers	Mr. Kaberia Chairman department and center of Centre
Mumias Sugar Co, Mumias	Solid waste disposal		✓	Require technical assistance on waste disposal & storage	Geneveine N. Wanyama Environmental supt. +25456641620/1
Rivertex East African limited	Back coatings	✓	✓	No fabric coating. Operational capacity of the factory is low	Mr. Simon Too Factory manager
Best mattress, Eldoret	PBDE, Polyurethane foam (PUR). Polyol additive	✓	✓	No burning on site. Recycling.	Mr. Mugaka Process manager, Eldoret
Rai plywoods, Eldoret	Adhesives and paints		✓	They make their adhesive glue from mixing paraformaldehyde and urea. Likely hood of the formation brominated or fluorinated compounds are minimal	George Thomas Technical manager Tel: 0733633811
Agro-chemical & food company Ltd Muhoroni	Solid waste disposal		✓	They don't have an incinerator. Likely hood of the formation brominated or fluorinated compounds are minimal	Mr. Reuben K. Odhiambo Box 18-40107 Muhoroni Peter Macharia Environmental & Safety
Kakamega provincial hospital	Hazardous Hospital waste & incineration		✓	Inefficient incinerator facility at the site.	Mrs. Gitari

4.1 Annex A substances, industrial chemicals (Hexabromobiphenyl and polybrominated diphenyl ether (tetra, penta, hexa and hepta BDE))

4.1.1 Hexabromobiphenyl (HBB)

It is therefore unlikely that there have been any significant HBB emissions to the environment after 2008, the year the Kenyan NIP was drafted. This is because HBB was banned in 1977 and products that had HBB flame retardants have a lifespan of five to ten years.

4.1.1.1 Current production, use, control and release pathways

HBB were banned for production in 1977. Kenya does not produce any products with HBB as additives. Plastics in use that were manufacture prior to the ban and imported in Kenya may be the only source of HBB in the Kenyan environment. There is unlikely such products exist.

4.1.1.2 Emission sources and release pathways

There are no reported releases of HBB in Kenya. It is also unlikely that there exist plastics in Kenya manufactured before the HBB ban.

4.1.1.3. Stockpiles, compliance activity and alternatives

There are no known stockpiles in Kenya. There are alternative flame retardants in the Kenyan market.

4.1.2 Polybrominated diphenyl ether (tetra, penta, hexa and hepta BDE)

Polybrominated diphenyl ethers (PBDEs) were additives in many electronic goods as flame retardants. It is therefore important to assess the quantities of electronics in Kenya.

4.1.2.1 Current production, use, control and release pathways

Most vehicles assembled before 2005 had PBDEs additives in various parts. Kenya assembles motor vehicles but majority of cars in Kenya are imported as ready-made. The major assembler companies in Kenya are the Kenya Vehicle Manufacturers (KVM) which also assembles for Hyundai Motor Corp and is located at Thika town, General Motors East Africa (GMEA), Honda Motorcycle Kenya Ltd, Associated Vehicle Assemblers Ltd (AVA) which also assembles for Toyota (East Africa), Toyota Kenya Ltd (TKL) and TVS Motors Kenya. Major retailers are the Toyota (East Africa)/ Toyota Kenya Ltd (TKL), Cooper Motor Corporation, General Motors East Africa (GMEA), Simba Colt and DT Dobie. The assembling or body building is mainly

done for buses and other mini buses. Cars imports from Asia are estimated to take the highest percentage of POP PBDE input in Kenya (see figure 4-1-2). This is generally because Kenyan main vehicles imports are from Asia. Enhanced trade with Asia is predicted to increase the POP PBDE to Kenya if the source countries do not restrict the use of PBDE additives in vehicles furnishes.

The table 4-1-2 gives the estimated inputs of POP-PBDEs in PUR foam in Kg of imported vehicles and exported annually based on import and export statistics.

Import region	**Vehicle type**	**Imports (in Kg)**	**Exports (in Kg)**
Asia	Cars	332.9	0.01
	Track	73.7	0
	Buses	38.3	0
Europe	Cars	22.9	0.054
	Track	5.5	0
	Buses	99.3	0
United States and North America	Cars	93.9	0
	Track	4.2	0
	Buses	6.5	0.06

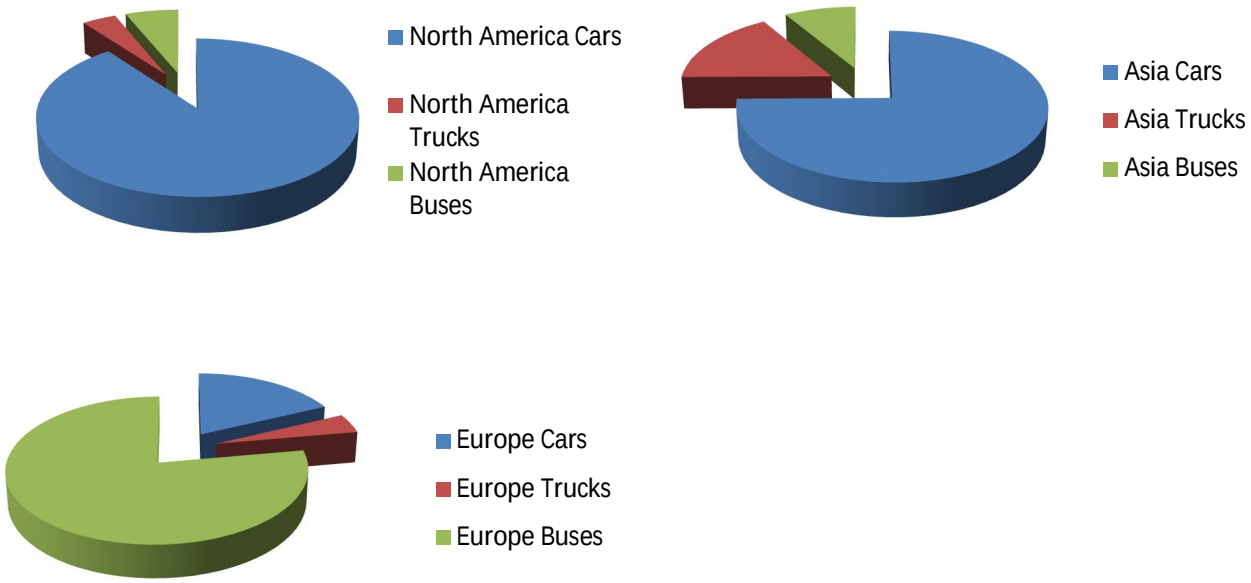

Figure 4-1: Contribution through motor vehicles imports and exports of POP PBDE in Kenya.

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). These study reports that some of the mattresses manufacturing industries use a formulation that contains a polymer polyol with contains flame retardants. Mattresses are therefore on pathway through which POP PBDE can enter the Kenyan environment. The lifespan of furniture in industrial countries is estimated at about 10 years. Historically, C-PentaBDE was also used in rigid PUR foam.

Kenya manufactures 2826 tonnes of mattresses and foams annually, with Vitafoam Ltd taking 60 % of the production. Countries with no specific flammability standards for furniture/mattresses can be considered to have low levels of POP-PBDEs in furniture and mattresses unless a significant amount of these materials have been imported from countries with specific flammability standards. Industrial manufactures visited did not specifically indicate the amounts of c-PentaBDE additives they use in manufacture. The amount is estimated to be relatively small in quantity. It is important to note that Kenya exports mattresses in a tune of 712.1 tonnes annually.

Electrical and electronic equipment

Electrical and electronic equipment is one of the fastest growing material flows of goods as well as a large waste and recycling flow. An inventory of EEE and WEEE hasbeen done in Kenay before (UNEP 2009). Since the CRT casings (TVs and computer monitors) are expected to contain more than 50 % of the total POP-PBDEs present in EEE, data calculated in the initial assessment could provide an estimate of the major portion of POP-PBDEs in the EEE/WEEE sector in the country.

Based on data from the KNBS and the KRA since the year 2005, the average amount of PBDEs in CRT and TV monitors per year based on export and import data in Kenya for five years are as follows; CRTs and TV monitor imports are 211.7 Kg and 520.9 Kg respectively, and 6.8 kg and 23.7 kg for exports respectively.

Kenya imports on average 8255.5 tonnes of computers and exports 432.8 tonnes out of which the amount of PBDEs in Computer traded is 780.1485 Kg in imports and 40.8978 Kg in export.

4.1.2.2 Emission sources and release pathways

The source of the PBDEs is likely from trace amounts that leach into air (indoor and outdoor) and sewage from products. Polybrominated diphenyl ether flame retardants tend to be additive, which means they are held in place physically, rather than chemically bonding to the polymer (plastic material) or fabrics as with reactive flame retardants. As a result, over time, PBDE molecules can be released will also depend on the environmental parameters and the property of the product. Resent research support the presence of PBDEs in offices and homes thus indicating emission through air ((Björklund et al 2009, Björklund et al 2011 and Thuresson at al 2011).

4.1.2.3 Stockpiles, compliance activity and alternatives

Data on e-Waste stockpiles in Kenya were reported elsewhere as 11,400 tonnes are generated from refrigerators, 2,800 tonnes from TVs, 2,500 tonnes from personal computers, 500 tonnes from printers and 150 tonnes from mobile phones (UNEP & UNU, 2009). The same report (UNEP & UNU, 2009) showed that 1,513 tonnes of electronics entered the market. The consumer in addition to receiving 1489.4 tonnes also received 151.3 tonnes from the second hand market. It was also revealed that consumers are likely to dispose 1,210.4 tonnes in the second-hard market, and 18.6 tonnes to collectors or as general waste which is sent to

refurbishers. The consumer disposes a further 18.6 tonnes directly to recyclers. Refurbishers and recyclers then send 605.2 tonnes for disposal. Alternatives for flame retardants in electronic products exist, though imports from other countries that have not affected the PBDE ban is a major pathway to PBDE in Kenya. The report gives an insight of how industrial POPs management is a challenges and calls for interventions. The PBDE released from these estimates can be calculated. The following table 4-1-3 shows the amount of E-waste and the respective POP-PBDEs in stocks of EEE in Kenya

Table 4-1-3: E-waste amount and the respective POP-PBDEs in stocks of EEE in Kenya annually

Product type	Amount of E-waste in tonnes/year	POP-PBDEs in stocks of EEE in Kg/year
Fridge	1400	50.4
TVs	2800	2133.6
Computers	2500	236.25
Printers	500	47.25
Mobile phones	150	5.4

Bereau B & G (1993) used the following approach calculating EEE articles entering the waste stream or WEEE flows, respectively (Streicher-Porte, 2006). The two key inputs for this calculation are (i) the amount of EEE stockpiled (see 4.3.1.2) by consumers and (ii) the average life span (combined time of being used and stored by consumers). These numbers were assessed through the consumer questionnaires as explained in the previous section.

WEEE generated per year = MEEE(*j*)stockpiled / lsEEE(*j*) …….(i)

Where

- MEEE(j)stockpiled is the amount of EEE (*j*) stockpiled at the consumer [in metric tons]
- lsEEE(*j*) is the average life span of the specific appliance (*j*) [in years] (combined time of being used and stored at the consumer)

Using equation (i), the EEE entering the waste stream can be calculated, given the lifespan of the EEE product. For example, the POP PBDE released to the waste stream by end of life computers

(life span for computers is 5 to 8 years) will range from 29.5 kg to 47.25 kg annually. The following table 4-1-4 shows the POP PBDE release to the waste stream annually.

Table 4-1-4: POP PBDE release to the waste stream annually in tonnes per year

Product	POP PBDE released in tonnes/year
PC+ Monitor	29.5 to 47.25 (Average 38.38)
Printer	9.45
Mobile Phones	1.35
TVs	91.35
Refrigerators	41.04

4.2 Annex B substances, Industrial chemicals (perfluorooctanesulfonic acid (PFOS), its salts and perfluorooctane sulfonyl fluoride (PFOS-F)

Perfluorooctane sulfonic acid (PFOS) is both intentionally produced and an unintended degradation product of related anthropogenic chemicals. PFOS is used as a surfactant in a number of firefighting foams and many other industrial applications (Kissa 2001). In Kenya, it comes in the formulations called fluoro protein foam and aqueous firefighting Foams (AFFF). Firefighting forms could be a significant source of PFOS in the Kenyan environment. The other significant source of PFOS is the use domestic market products, particularly as a stain repellent in furniture and other furnishing items. These items, which are still being used, are likely to remain a source of PFOS emissions for an extended period.

4.2.1 Current production, marketing, use and control

Table 4-2 shows extracted data from the KNBS on reported quantities of imports and in-transit exports of PFOS-based fire-fighting foams since 2005.

Table 4-2: Import and Export data of Firefighting foam containers in Kenya between the years 2005 to 2012.

Year	Imports	Exports/transit to other countries
2005	1156150	47257
2006	1304651	101635.6
2007	1373201	38172
2008	1190848	117381
2009	1249051	153513
2010	5895383	117348
2011	1591617	103211
2012	1701403	82354

Sourse: KNBS and KPA

Between 2005 to 2012, Kenya imported a total of 15462304 containers of firefighting foams.

There are theree major firefighter companies in Nairobi which include the city council and the G4S security company. The two companies offer training services to various firefighting companies. In average, the amount of firefighting foam used by G4S is 12000 liters. The amount of PFOS and related chemical released in the Environment per year is therefore between 60 kg to 180 kg per (120 kg average). The city council of Nairobi uses 4000 and 30000 of the Fluoroprotein and AFFF respectively. That will release a range of between, 20 to 60 (average of 40 kg per year) and 150 to 450 (average of 300 kg per year) kg per year of fluoroprotein and AFFF respectively, giving a total 340 kg per year. A total 460 kg/year of PFOS and related chemicals release are notified by the two companies.

4.2.2 Emission sources and release pathways

The release of PFOS and related chemicals in Kenya is mostly through firefighting and during training of firefighting personnel. It is expected that major contamination site will be at firefighting training facilities. One such facility is based at Naivasha. It is likely that PFOS-based foam has previously been more widely used, but it is not possible to make a quantitative estimate of emissions.

In the Kenya, current use of PFOS includes metal plating activities in the chrome industry, the use of small quantities in semi-conductor manufacture and limited applications in the photographic industry. In Kenya, the main environmental release pathways are believed to be to

water through the waste water treatment works. The following table 4-2-2 shows the contribution significance of release of PFOS per product category.

Table 4-2-2: Contribution by product categories in Kenya for PFOS release.

Product category	Base compound	Significance		
Textiles and upholstery			significant	
Synthetic carpets			significant	
Leather and apparel				minor
Paper and packaging	Mono-, di- or triphosphate esters of N-ethyl perfluorooctane sulfonamidoethanol (EtFOSE) N-Methyl perfluorooctane sulfonamidoethanol acrylate polymers	Major		
Industrial and household surfactants (cleaning agents, floor polishes and auto polishes)	Potassium N-ethyl-N-[(heptadecafluorooctyl)sulfonyl] glycinate		significant	
Coating, paint and varnishes			significant	
Toner and printing ink	N-ethyl-N-[3-(trimethoxysilyl)propyl] perfluorooctane sulfonamide			Minor
Sealants and adhesive products				Minor
Medical devices (Video endoscopes)	ethylene tetrafluoroethylene (ETFE) copolymer layer.			minor
Fire-fighting foams	AFFF and Fluoroprotein	Major		
Aviation hydraulic fluids		Major		
Insecticides	N-Ethyl perfluorooctane sulphonamide. IUPAC name is 1-octanesulphonamide-N-ethyl-heptadecafluoro sulfluramid.			Minor
Metal plating industry • Metal plating in closed loop-system • Hard metal plating • Decorative metal plating			significant	
Photographic and Photolithography industry (Photoimaging)		Minor		

4.2.3 Stockpiles, compliance activity and alternatives

Nairobi County's total stockpiles of PFOS-based foam are estimated at 40000 litres and it is in open storage facility at the premises in industrial area of Nairobi (See figure 4-1). Most fire and rescue services reported that they had no stockpiles of PFOS-based foams, while a few had small quantities. The inventory did not include all Kenya's fire and rescue services, but the information received is believed to be representative of this category as a whole. The Kenyan Armed Forces also have considerable remaining stocks of PFOS-based foam. It is estimated that the total content of PFOS-related substances in foam stockpiles in all municipal councils in Kenya is approximately 80 tonnes. Figure 4-2 show open storage of AFFF at a Nairobi`s industrial area facility.

Figure 4-2: Storage of AFFF and Fluoroprotein foam at a Nairobi premises.

Section 5

5.0 Implementation of action on Industrial Persistent Organic Pollutants

The capacity to manage waste has been a challenge in Kenya, not only for POPs but all forms of waste which includes industrial wastes. Luck of proper technology to handle waste. Inadequate trained personnel in handling and disposal of wastes, luck of public awareness. This inadequacy has resulted to dumping and burning of waste in undesignated area within municipalities in Kenya. Disposal facilities such as incinerators are also inadequate. However, there are efforts to come up with sanitary landfills. Several hospitals have been ISO 1400 certified to handle medical waste which are also a source of Industrial POPs.

Currently there is no monitoring of industrial Pops in Kenya. However, research has been done to establish the levels of Perfluorinated compounds in various environmental matrices of Lake Victoria (Orata *et al* 2009, Orata *et al* 2011).

5.1 Disposal of products containing industrial POPs in Kenya

Luck of information by all sectors stakeholders has led to in proper disposal of waste containing PFOS and related substances. Proper disposal and handling of E-waste in Kenya goes hand in hand in reduction of PBDE in the environment. For E-waste, Kenya has a number of projects geared towards recycling and disposal. They include the following;

- Computer for Schools through their refurbishment programme
- WEEE compliant recycling at Athi river, Nairobi (the HP project. See Figure 5-1)
- Support of individual companies in their projects. Examples are the Nokia Company through their recycling scheme. Companies such as IBM and XP have a program where e-waste from their products are transported back to their homeland.

At the East African compliant recycling, 6000 kg per day of CRTs and 6000 kg per day of LCDs are sorted out, different plastic polymer types separated for either recycling or disposal. Hazardous parts are sent back to the UK for disposal. Apart from the CRTs and LCDs, 30000kg of other electronics are sorted per per year. Collection centers that feed the facilities within

Nairobi are at Mukuru, Ngara, Dandora, Eastlands, Kibera . The Hazardous waste is sealed in containers and transported back to the UK for further treatment and disposal.

Figure 5-1: Best practice in e-waste handling and disposal at the premises of East African Compliant recycling Athi river. A HP project.

The practices for managing e-waste are mostly handled by the informal sector (*Jua Kali*). Most of these operators have inadequate skills, are neither registered nor authorized and operate in a

secretive manner. These operations are well connected to the supply chain processes of sourcing the raw material to finding markets for the recovered materials during post-recycling operations. The processes are highly toxic and impact adversely to both the environment and human health.

5.2 Monitoring of Industrial POPs in Kenya.

In Kenya, monitoring of PFOS was done in the Lake Victoria catchment of Kenya. The study revealed the presence of PFOS in surface water, sediments and fish (Orata et al 2008, Orata et al 2009, Orata et al 2011). The levels found were in ng/g levels and are shown in table 5-2 and Figure 5-2.

Table 5-2. Concentrations range and mean with standard error (in brackets) in ng/g of PFOS and PFOA in muscles and liver of *Lates niloticus* and *Oreochromis niloticus* obtained from various sampling locations in Lake Victoria.

		PFOS (ng/g)		PFOA (ng/g)	
Sampling Location	**Fish species**	**Muscles**	**Liver**	**Muscles**	**Liver**
Dunga Beach	Lates niloticus	1.00 -10.50 (4.15 ±2.09)	6.20 -11.40 (8.55 ±0.85)	<0.50- 2.20* 2.20	<0.50- 1.80* (1.18 ±0.60)
	Oreochromis niloticus	0.90 -12.40 (4.89 ±2.11)	1.50 – 19.70 (10.01 ±3.21)	<0.50- 0.90* (0.90)	<0.50- 1.90* (1.90)
Nyamware beach	Lates niloticus	1.00 – 9.41 (3.11 ±1.59)	15.03-35.70 (24.35 ±3.60)	<0.50	<0.50- 3.80* (2.06 ±0.28)
	Oreochromis niloticus	1.20 – 8.00 (3.70 ±1.17)	24.00 – 23.70 (11.75 ±3.70)	<0.50	<0.50- 1.00* (1.00)
Ndura Beach	Lates niloticus	0.90 – 5.00 (2.70 ±0.66)	1.40 – 13.20 (6.90 ±1.90)	<0.50	<0.50-1.20* (1.20)
	Oreochromis niloticus	0.90 – 3.00 (1.86 ±0.38)	2.60 – 14.20 (6.95 ±0.97)	<0.50	<0.50-1.00* (1.00)
Kusa Beach	Lates niloticus	1.00 – 2.20 (1.83 ±0.21)	2.20 – 5.60 (4.20 ±0.58)	<0.50	<0.50
	Oreochromis niloticus	1.00 – 2.00 (1.23 ±0.19)	4.20 – 7.30 (5.64 ±0.52)	<0.50	<0.50
Kendu bay pier Beach	Lates niloticus	1.80 – 3.20 (2.20 ±0.25)	3.20 – 6.70 (4.95 ±0.57)	<0.50	<0.50- 1.10* (1.10)
	Oreochromis niloticus	1.20 – 2.40 (1.80 ±0.21)	2.30 – 5.60 (4.15 ±0.55)	<0.50	<0.50

*Only one to two samples are above the limit of quantification. Values below LOQ are donated by ` < `. Values below the LOQ were not included in the estimation of the mean.

The levels obtained in fish and surface water in the Victoria catchment area were found not pose immediate danger to consumers. Figure 5-1 below shows a histogram of PFOS concentrations in water at various sites in Kisumu city of Kenya.

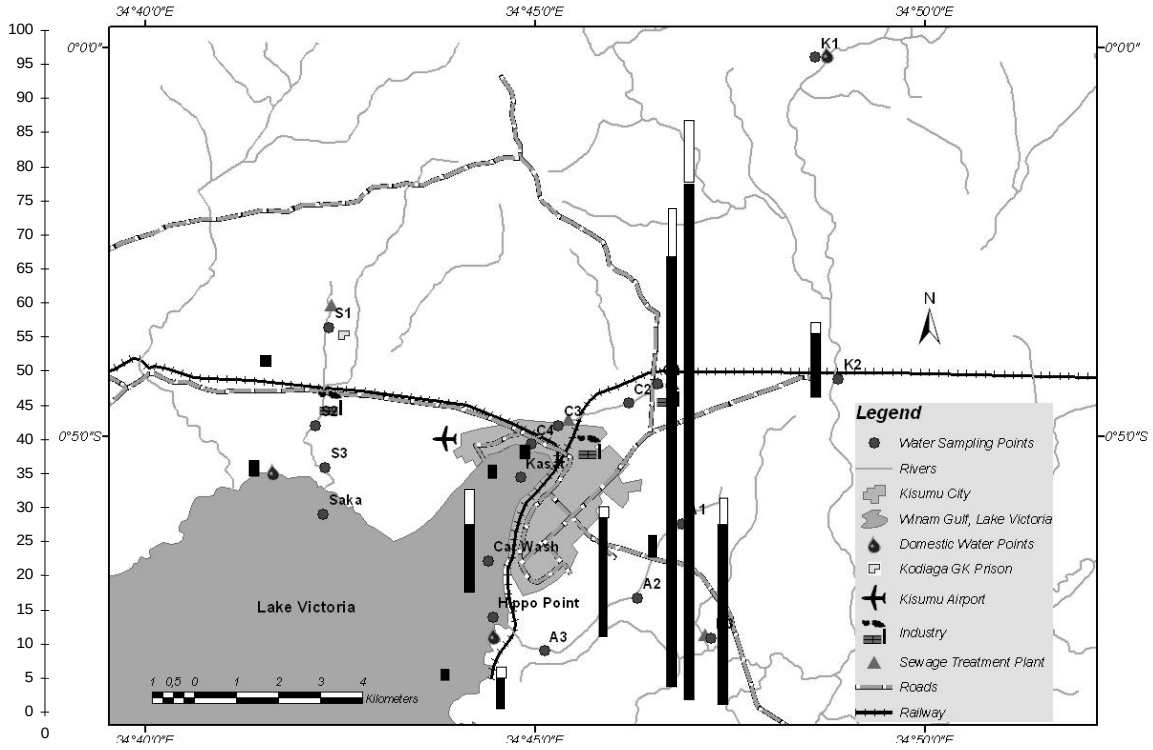

Figure 5-1: Concentrations (ng/L) of PFOA (black bars) and PFOS (White bars) in water in Kisumu Kenya

No levels have been monitored for POPs-PBDE and HBB in any environmental matrices in Kenya. The need to monitor these levels is therefore recommended.

5.3 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 rebound and regrinding. In Kenya, there is informal and formal recycling of matrasses and foams to make new products for the market. The resulting new articles need to be captured by an inventory.

5.4 Potential contaminated sites

Landfills are the ultimate destination of many POP-PBDEs-containing materials due to their widespread application in a multitude of consumer and industrial goods. In Kenya, every town has a landfill in form of an open dumb site. POP-PBDEs can be leached from refuse by landfill leachate, to drainage systems. For PFOS, firefighting training grounds are a potential source of contamination.

5.5 BAT and BEP for the use of PFOS and related chemicals

According to the Guidance on best available techniques (BAT) and best environmental practices (BEP) for the use of perfluorooctane sulfonic acid (PFOS) and related (Draft, 2012) (new), there is need for proper storage of products containing PFOS. The manufacturing processes should be in a closed system at limited sites. Reactors, containers and pipes containing PFOS-related feedstock should be regularly maintained to avoid leakages.

For waste collection and disposal, high temperature incineration could be a reliable way to treat such PFOS-contained waste. The incinerators must meet the required standards which include high temperature of around 1500° C. As observed recently during reconnaissance study trip to one of the firefighting facilities within Nairobi City, there was open air storage, which is not recommended for PFOS containing products.

Labels on the containers of products containing PFOS and PFOS-related substances or precursor should include the concentration and the material safety data sheet (MSDS). Regular monitoring of concentrations in the environment is important.

For developing economy country like Kenya, it is important that policies restricting imports of End of Life goods like textiles (locally known as Mitumba) adhered to.

Table 5-5: BAT and BET for respective sectors handling PFOS and related substances in Kenya

Sectors	BEP & BAT
Textiles Synthetic carpets Paper and packaging Industrial and household surfactants Coating, paint and varnishes Mattresses and foams	• Buy products and materials from compliant countries • Store products in dry and enclosed areas. • Avoid burning • Incineration at 1500°C • Labels on the containers of products containing PFOS and PFOS-related substances • Acid treatment of stockpiles
Fire-fighting foams	• Use alternatives, • Avoid using the foam in trying areas
Aviation hydraulic fluids	• Store products in dry and enclosed areas. • Acid treatment of stockpiles
Insecticides	• Store products in dry and enclosed areas. • Acid treatment of stockpiles
Metal plating industry/chrome plating	• Store products in dry and enclosed areas. • Use of alternatives
Dumpsites & stockpiles	• Acid treatment & inceneration • Handle at production areas

5.5.1 Alternative fluorochemical based firefighting foam

The use of alternative to AFFF and fluoro protein that are used in firefighting foam is an important step in reducing or eliminating their health risk. Currently, continuous research is going on for the use of alternative (Seow, 2013). The researched is based on using fluorine free firefighting foam and towards shorter chain (< C6) perfluorinated chain. Shorter chain perfluorinated reduces the risk of toxicity and bioaccumulation potential (Seow 2013, Robin Vestergren & Francis Orata et al., 2012)

5.6 BAT and BEP for the use of POPs PBDE and HBB

Measures and safety precautions that apply to all types of products and industries related to PBDE in the are summarized in the guidance on BAT and BEP for the recycling and waste disposal of articles containing polybrominated diphenyl ethers (PBDEs) listed under the

Stockholm Convention on POPs (Draft, 2012). These involve emphasis on the use of alternatives. Of importance, the BAT and BEP should aim at minimizing the usage of products that contain POPs PBDE and HBB. Proper disposal of end of life goods such as electronics, vehicles and household is mandatory. Products containing PBDE flame retardants or their precursor should be labeled and MSDS attached. New imports of goods containing these chemicals should be stopped and alternatives import encouraged. Regular monitoring of concentrations in the environment is important. Secondly, a country can export hazardous waste if it does not have the technical capacity, necessary facilities or suitable disposal sites to handle the waste in question in an environmentally sound and efficient manner. Steps must be taken to minimise pollution and its consequences for health as far as possible. It should, however, be noted that most developing countries are yet to legislate law and guidelines on e-waste and continue to act as dumping sites from developed countries.

Table 5-6: BAT and BET for respective sectors handling POP-PBDE and HBB in Kenya

Sectors/category	**Product**	**BEP & BAT**
Transport	Buses, Trucks, Cars, Motorcycles	• Require policy on end of life vehicles. • No open storage fro end of life vehicles • Recycling the PUR foam • Incineration of the PUR foam at 1500°C
Electronics	Computers/Printers/Copiers Mobile phones Radio Refrigerators Electric cables	• Buy parts that use alternatives • Avoid importation of second hand electronics • Waste separation, recycling and reuse, • Send hazardous waste to countries with BAT
Furniture, mattresses & textiles	Mattresses and Foam	• No open burning, in case of burning, incinerate at 1800°C • Recycling • Labels on the containers of products
Recyclers		• Labels on the containers of products • Send hazardous waste back to country of origin

5.6.1 Alternative flame retardants to PBDEs

New flame retardant solutions are constantly introduced in the market to replace the POP-PBDEs. Alternative flame retardants available are classified in the following categories: Inorganic flame retardants and synergists (Aluminium hydroxide, Magnesium hydroxide, Red phosphorus, Ammonium polyphosphate, Antimony trioxide, Zinc hydroxystannate, and Zinc stannate) Organophosphorus flame retardants (Triethyl phosphate, Aryl phosphates) Halogen containing phosphorus flame retardants (Several halogen containing phosphates, such as chloro- and bromophosphates). An overview of available alternatives are shown in Table 5-6.

Table 5-6: Overview of use of alternative flame retardants to PBDEs in several materials and applications.

Materials /polymers /resins	Inorganic alternatives to PentaBDE	Phosphorus/nitrogen organic alternatives to PentaBDE	Halogen organic alternatives to PentaBDE	Alternative flame Retardant materials	Applications	Commercial commodities for the applications
Epoxy resins	Aluminium hydroxide Magnesium Hydroxide Ammonium poly Phosphate Red phosphorus Zinc hydroxystannate, Zinc stannate	Metallic phosphinates Reactive nitrogen and phosphorus constituents (unspecified)	Tetrabromobis phenol A (reactive) Etylenebis (tetrabromo) phtalimid	Polyethylene sulphide	Circuit boards, protective coatings	Computers, ship interiors, Electronic parts.
Polyvinylchloride (PVC)	Aluminium hydroxide Zinc borate Zinc molybdenum compounds (together with phosphate esters) Zinc hydroxystannate, Zinc stannate	Tricresyl phosphate (also plasticizer)	Tris (dichloropropyl) Phosphate Vinylbromide	Rigid PVC is flame inherent itself	Cable sheets	Wire end cables, floor mats, industrial sheets.
Polyurethane (PUR)	Ammonium poly Phosphate Red phosphorus	Melamine (nitrogen based) Dimethyl propyl Phosphonate (DMPP)	Bromoalkyl Phosphates Tetrabromophtalic anhydride Tris(chloroethyl)	Intumescent systems	Cushioning materials, packaging, padding	Furniture, sound insulation packaging, padding panels, wood imitations, transportation.

		Reofos (nonhalogen Flame retardant)	phosphate (together with brominated polyols or red phosphorus)			
Unsaturated (Thermoset) polyesters (UPE)	Ammonium Polyphosphate Aluminium hydroxide Magnesium Hydroxide Zinc Hydroxystannate, Zinc stannate	Triethyl Phosphate Dimethyl propyl phosphonate	Dibromostyrene Tetrabromophtalic anhydride based diol, Tetrabromophtalic Anhydride Bis (tribromophenoxy) ethane	Intumescent systems	Circuit boards, coatings	Electrical equipment, Coatings coatings for chemical processing plants mouldings, military and marine applications: construction panels.
Rubber	N/A	Alkyl diaryl phosphates (nitril rubber)	N/A	Intumescent systems	Transportation	Conveyor belts, foamed pipes for insulation.
Paints/lacquers	N/A	Triaryl phosphates (unspecified)	Tetrabromo phthalate diol Tetrabromophtalic anhydride based diol Bis (tribromophenoxy) Ethane	Intumescent Systems Silicone rubber	Coatings	Marine and industry lacquers for protection of containers
Textiles	Aluminium Hydroxide Magnesium Hydroxide Ammonium compounds (unspecified) Borax	Tetrakis hydroxymethy l phosphonium salts such as chloride or ammonium Dimethyl phosphono (N-methylol) Propionamide Diguanidine hydrogen phosphate Aromatic phosphates	Trichloropropyl phosphate	Intumescent Systems Aramide fibres (certain protective applications) Wool Modacrylic	Coatings	Back coatings and impregnation for carpets, automotive seating, furniture in homes and public buildings, aircraft, underground.

		(unspecified) Dimethyl hydrogen phosphite Melamine (nitrogen based) Phospho nitrilic chloride				
Hydraulic oils	N/A	Butylated triphenyl Phosphate esters	N/A	N/A	Drilling oils, hydraulic fluids	Off shore, coal mining

6.0 Conclusion

Industrial POPs are still in circulation in the Kenyan environment. POP-PBDE although banned for production and use a decade ago, materials and products containing PBDEs are still in use in Kenya and thus we expect that there if continual emission of PBDEs in the environment. Plastic products treated with HBB are expected to have a lifespan ranging from five to ten years. It is therefore unlikely that there have been any significant HBB emissions to the environment after 1990.PFOS and related substances are restricted in use. Analysis of environmental samples by Orata et al (2009, 2011) revealed the presence of PFOS in the environment in Kenya. The study showed that poor municipal waste storage and disposal contributes to the release of PFOS and eventually in surface water systems. The leading source of PFOS and related substances is the imports of AFFF used for firefighting. A significant amount may also be through imports and use of domestic appliances in Kenya as observed through environmental matrices (sediments, water and even fish) analyzed for PFOS. Hazardous waste disposal in Kenya is still a big challenge. For example, there are inadequate incineration facilities in the country in general.

The challenge Kenya faces in its mandatory obligation to Stockholm convention is lack of awareness by key stockholders on industrial POPs. The consequence of luck of awareness by stakeholders has resulted in imports of these chemicals, unregulated cross border movements of products containing industrial POPs. The current estimates of industrial POPs in products and what is being generated annually in Kenya is 677.2 Kg from Motor vehicles, 211.7 kg from CRTs, 520.9 kg from TVs, 780.1 kg from Computers for POP-PBDE. For PFOS and related substances, 9200 Kg of AFFF and fluoroprotein are released every year in the environment through firefighting processes and training fire personnel. The release of Industrial POPs to the Kenyan environment is through poor waste disposal methods and storage. Poor disposal and storage methods expose both POP-PBDEs and PFOS and related substances to the environment and ultimately a risk to human. The use and application of PBDEs in products in Kenya is heavily dependent on import materials. This is because PBDEs are not manufactured in Kenya.

Recycled products such as vehicles and imported electronic (end of life) goods such as computers for reuse being the main sources of the PBDEs. Without strict regulation, this can be termed as the "dumping" of such products from others countries. PBDEs containing raw materials mainly polymers may also be a significant source i.e in mattress, foam and plastic manufacturing industries in Kenya.

6.1 Recommendation

- Industrial POPs awareness campaign targeting all stake holders who are; Kenyan industrial sector, Policy makers and implementers.
- Environmental monitoring programs must be enhanced. This will include analysis of the industrial POPs in the environment. Because of the complexity of the research, the private sector, government institutions must partner with research institutions and universities.
- Best available techniques (BAT) and best environmental practices (BEP) for both PBDEs and PFOS and related substances must be observed by industries that deal with the POPs materials and products.
- Alternatives for PBDEs that are available should be used. Although research is being undertaken to find alternatives to fluorine based surfactants for industrial purposes, industries should be encouraged to use fluorine free materials and products.

6.2 Action Plan, Legal and Policy issues to be addressed

Policy issues that address that will play a role in controlling the use and eventual release of the newly listed industrial pollutants in Kenya should involve.

- Restrictions on Mitumba (second hand clothes) to stop the importation of textiles coated with PFOS and related substances.
- Programs where electronic equipment's and products are recycled in Kenya i.e. computer for schools program must be restricted. Policy to that address the life span of the imported electronics should be put in place to avoid dumping of end of life electronics in Kenya.
- Policy on end of life vehicles is required, policy that consider the life span of electronic waste be formulated. This should include storage, disposal and recycling of these products parts.
- Importation of products from compliant companies or countries is necessary. PBDEs are banned under the Stockholm convention and their products should be banned for use in Kenya. For PFOS and related substances, only use of products that are exempted for use should be allowed. Exemptions for PFOS under Regulation are as follows: in controlled electroplating systems; for photolithography processes; photographic coatings; suppressants for non- decorative hard chromium (VI) plating in closed loop systems; hydraulic fluids for aviation.

6.2.1. Action plan and budgetary implications.

Action plan and budgetary implications for Newly Listed Industrial POPs in Kenya both short term and long term action on newly listed industrial POPs are shown in tables 6-2-1 and 6-2-2.

Table 6-2-1: Action plan and budgetary implications for Newly Listed Industrial POPs in Kenya. Short Term Action on newly listed industrial POPs

POP	Objective	Activity	Responsibility	Time scale	Cost (Ksh)
PFOS and related substances	Management of already identified newly listed industrial POPs	Labeling of materials and products	NEMA/Customs/KPA/Industries/ Owners	1 year	2 million
		Awareness to stakeholders	All stake holders	2 year	5 million
		Monitoring in environmental matrices	Universities/Research institutes/ Government laboratories	2 year	10 million
		Clean-up contaminated sites	County governments/Central Governments	1 year	10 million
		Proper storage and disposal programs	All stake holders	2 Year	5 million
	Detailed inventory of other sources	Inventory on already existing PFOS and PFOSF	Consultants/experts	1 year	5 million
	Capacity building programs for sustainable POPs management	Awareness	All stakeholders	1 year	3 million
		Training	Industry/Government and county officers/MSC and PHD students	5 Year	20 million
		Analytical methods development	Universities/Research Institutions	1 year	3 million
POP-PBDE	Management of already identified newly listed industrial POPs	Labeling of materials and products	NEMA/Customs/KPA/Industries/ Owners	1 year	2 million
		Awareness to stakeholders	All stake holders	1 year	2 million
		Monitoring in environmental matrices	Universities/Research institutes/ Government laboratories	1 year	5 million
		Clean-up contaminated	County governments/Central	1 year	2 million

		sites	Governments		
		Proper storage and disposal programs	All stake holders	½ Year	1 million
	Detailed inventory of other sources	Inventory on already existing PBDEs	Consultants/experts	1 year	5 million
	Capacity building programs for sustainable POPs management	Awareness	All stakeholders	1 year	1½ million
		Training	Industry/Government and county officers/MSC and PHD students	1 Year	5 million
		Analytical methods development	Universities/Research Institutions	1 year	3 million
Hexabromobiphenyl	Management of already identified newly listed industrial POPs	N/A	N/A	N/A	-
	Detailed inventory of other sources	N/A	N/A	N/A	-
	Capacity building programs for sustainable POPs management	N/A	N/A	N/A	-
				Total	**89.5 millions**

Table 6-2-2: Action plan and budgetary implications for Newly Listed Industrial POPs in Kenya. Long Term Action on newly listed industrial POPs

POP	Objective	Activity	Action	Schedule	Cost (Ksh)
PFOS and related substances	Policy and regulation framework	Policy formulation on PFOS and PFOSF	NEMA/GOK/Stakeholders/Attorney generals chamber		5 million
		Regulatory standards			
		Stakeholders sensitization			
		Enforcement			
	Development strategies for management of POPs	Identify areas that require technical input	NEMA	2 year	4 millions
		Develop monitoring and evaluation strategies, both technical and managerial	NEMA		
		Phasing out PFOS and related substances	NEMA		
		Educate users	NEMA/GOK		
		Develop policies on PFOS and related substances	NEMA		
	Information exchange and public information	Establish data bank for users	NEMA/Stakeholders/GOK ministries i.e Ministries of education	2 year	3 millions
		Regulate findings and publications			
		Networking and information sharing for stakeholders			
		Incorporate environmental issues in post curriculum			
POP-PBDE	Policy and regulation framework	Policy formulation on POP-PBDE	NEMA/GOK/Stakeholders/Attorney generals chamber		5 million
		Regulatory standards			
		Stakeholders sensitization			
		Enforcement			
	Development strategies for management of	Identify areas that require technical input	NEMA	2 year	4 millions

	POPs	Develop monitoring and evaluation strategies, both technical and managerial	NEMA		
		Educate users	NEMA/GOK		
		Develop policies on PFOS and related substances	NEMA		
	Information exchange and public information	Establish data bank for users	NEMA/Stakeholders/GOK ministries i.e Ministries of education	2 years	3 millions
		Regulate findings and publications			
		Networking and information sharing for stakeholders			
		Incorporate environmental issues in post curriculum			
Hexabromobiphenyl	Policy and regulation framework	Policy formulation on POP-PBDE Stakeholders sensitization Enforcement	NEMA/GOK/Stakeholders/Attorney generals chamber		1 million
	Development strategies for management of POPs	Educate users	NEMA/GOK		1 million
	Information exchange and public information	Networking and information sharing for stakeholders	NEMA/Stakeholders/GOK ministries i.e Ministries of education		1 million
				Total	**27 million**

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ANNEX 1
Glossary of Terms and Units used

ABS	Acrylonitrile Butadiene Styrene plastic
AFFF	Aqueous Film-Forming Foam
BAT	Best Available Techniques
BFR	Brominated Flame Retardants
EEE	Electrical and Electronic Equipment
Fluoroprotein	Fluorinated surfactants in a carefully formulated protein foam liquid base
GMEA	General Motors East Africa
HBB	Hexabromobyphenyl
JKIA	Jomo Kenyatta International Airport
K.N.B.S	Kenya national Bureau of Statistics
K.R.A	Kenya Revenue Authority
KVM	Kenya Vehicles manufacturers
Mitumba	Second hand clothes and textile
MSDS	Material Safety Data Sheet
NIPs	National Implementation Plans
ng	Nanogram (10-9 g)
PBT	Persistent, Bioaccumulative, and Toxic
PBDEs	Polybrominated diphenylethers
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctane sulfonate
PFOS-F	Perfluorooctane sulfonic fluoride

Perluorinated Compounds	Compounds with chemical formula $(C_nF_{2n+1}COOH,)$ and $(C_nF_{2n+1}SO_3H,)$
POPs	Persistent Organic Pollutants
POP PBDEs	Polybrominated diphenylethers Persistent Organic Pollutants
PUR foam	Polyurethane foam
pg	Picogram (10-12 g)
TKL	Toyota Kenya Ltd
UN	United Nations
UNEP	United Nations Environment Programme
WEEE	Waste of Electrical and Electronic Equipment
WHO	World Health Organization

ANNEX 2

Table Annex 2.1: Descriptions of the industrial persistent organic pollutants

Hexabromobiphenyl	Is an industrial chemical that has been used as a flame retardant, mainly in the 1970s. It is no longer produced or used in most countries.
Hexabromodiphenyl ether and Heptabromodiphenyl ether	Are the main components of commercial octabromodiphenyl ether which has been used as a flame retardant. The only degradation pathway is through debromination and producing other bromodiphenyl ethers.
Tetrabromodiphenyl ether and pentabromodiphenyl ether	Are the main components of commercial pentabromodiphenyl ether which has been used as a flame retardant.
Perfluoroctane sulfonic acid (PFOS), its salts and Perfluorooctane sulfonyl fluoride (PFOS-F)	PFOS is both intentionally produced and an unintended degradation product of related anthropogenic chemicals. The current intentional use of PFOS is widespread and includes: electric and electronic parts, firefighting foam, photo imaging, hydraulic fluids and textiles.

Annex 2.2: Use the following equation to estimate the total quantity of PFOS used in industrial processes

$$T=L\cdot C$$

T= Total quantity of PFOS used in the industrial process per year
L= PFOS concentration or % of PFOS in the chemical agent /drilling fluid/chemical formula
C= Yearly consumption of the chemical agent/drilling fluid/ chemical formula

Annex 2.3: For the total quantity of PFOS in firefighting foam consumed yearly and in stockpiles, the estimation is done using the following equation:

$$T=L\cdot X$$

T= Total quantity of PFOS in firefighting foam consumed yearly
L= Percentage of PFOS in the grade of firefighting foam
X= National consumption of firefighting foam or in stockpile in tons per year

Table Annex 2.4: Concentrations of PFOS in different chemical formulas and products

Chemical formulas and products	**Concentrations of PFOS in chemical formula/product in wt %***	**References**
Aviation hydraulic fluids	0.05 - 0.1 %	DEFRA 2004
Fire fighting foam	0.5-1.5 %	DEFRA 2004
Textile formula/polymer	1.0-2.0%	(Posner et al. 2011)
Impregnation formula for synthetic carpets	2-5 %	(Posner et al. 2011)
Impregnation formula for leather	about 1 %	UKEA 2004
Impregnation formula for paper and paperboard	about 1 %	(Posner et al. 2011)
Coatings	0.1-1%	UKEA 2004
Insecticide	0.01-0.1%	UNEP 2010b

Table Annex 2.5: Concentrations of PFOS or related substances applied to different consumer articles

*1mg/kg = 1ppm = 0.0001%

Consumer article	**Concentrations of PFOS in material***	**References**
Textiles and upholstery	2-3 % of the fibre weight	RIKZ 2002
Synthetic carpets	0.03 % of the fibre weight	European Commission 2011
Leather	0.025-0.05 % by weight of material	RIKZ 2002; European Commission 2011
Paper and paperboard	1%	Kara et al. 2010
Industrial and household cleaning products	0.005%-0.1 % by weight of material	UNEP 2010b
Surface coating, paint and varnishes	0.01 % by weight of material	UNEP 2010b
Medical devices	150 ng in one CCD-colour filter	UNEP 2010b
Toner and printing inks	0.01 % by weight of material	UNEP 2010b
Cleaning agents, waxes and polishes for cars and floors	0.005-0.01% by weight of material	UNEP 2010b

If the concentrations applied have not been received from the stakeholders the concentrations given in Table can be used.

$$T=A\cdot W\cdot S$$

T= Total quantity of PFOS in articles sold on the market per year
A= PFOS amount applied by weight of material, by fibre weight, or % PFOS in the material
W= Weight of material in one article, or the fibre weight
S= Average number of articles sold on the market per year

Annex 2.6: Guidance formula used for calculating POP-PBDE inventory in vehicles

The following basic formula from the *POP-PBDE Inventory Guidance* is used to calculate the POP-PBDEs content of vehicles for the different categories (cars/trucks or busses) in the live cycle stages:

Amount of POP-PBDEs (Vehicle category) =

$$\text{Number of vehicles}_{\text{category}} \text{ (manufactured 1975 to 2013) x amount POP-PBDEs}_{\text{category}} \text{ x } F_{\text{regional}}$$

Where:

- *Number of vehicles*$_{category}$ is the number of vehicles (manufactured 1975-2013) present in a category (car, bus or truck) calculated for the different life cycle stages.
- *Amount POP-PBDEs*$_{category}$ is the amount of POP-PBDEs in a individual car, truck or bus treated with POP-PBDEs
- $F_{regional}$ The regional factor of estimated percentage of POP-PBDE impacted vehicles produced in a region (1975s to 2013)

Table Annex 2.7: Amount of POP-PBDEs in PUR foam of vehicles in current use/sale in the inventory year

Number of cars/trucks (manufactured in US before 2005)	Amount of c-PentaBDE per car/truck	Total amount POP-PBDEs in cars in use manufactured in US
	160 g per car	**No. of cars and trucks x 0.16 kg x 0.5*= _____kg**
Number of cars/trucks in use (manufactured in other regions before 2005)	Amount of c-PentaBDE per car	Total amount POP-PBDEs in cars in use (manufactured in regions other than US)
	160 g per car	**No. of cars and trucks x 0.16 kg x 0.05*= _____kg**
Number of buses in use (manufactured in US before 2005)	Amount of c-PentaBDE per bus	Total amount PBDE in buses in use (manufactured in US)
	1000 g per bus	**No. of buses x 1 kg x 0.5*= _____kg**
Number of buses in use (manufactured in other regions before 2005)	Amount of c-PentaBDE per bus	Total amount POP-PBDEs in cars in use (manufactured in regions other than US)
	1000 g per bus	**No. of buses x 1 kg x 0.05*= _____kg**
Total c-PentaBDE	-	**Sum of c-PentaBDE: _____kg**

Annex 2.8: Electrical and electronic equipment (EEE) and waste electrical and electronic equipment (WEEE)

The amount of total POP-PBDEs in EEE can be calculated as:

MPBDE(*i*) = MEEE(*j*) **x** fPolymer(k) **x** CPBDE(*i*);Polymer(k)

Where:

- MPBDE(*i*) is the amount of POP-PBDEs (*i*) in [kg] (in Polymer (*k*) of electrical and electronic equipment (EEE) (*j*))

- MEEE(*j*) is the amount of EEE (*j*) in [in tonnes] (imported, stockpiled or entering the waste stream)
- fPolymer is the total polymer fraction in [weight-%]
- CPBDE(*i*);Polymer is the content of the POP-PBDEs (*i*) in the total polymer fraction in [kg/tonne]

Information needed:

-amount of EEE/WEEE in the country,

- share of the relevant polymers in different EEE/WEEE categories and POP-PBDEs content of those polymers.

Information on WEEE polymers recycled and exported and the amount of WEEE polymers imported is also needed for the in-depth inventory.

Annex 2.9: POP-PBDEs amount in CRT in the country.

Once the per capita data have been estimated, the POP-PBDEs content in CRT casings (TVs and computer monitors).

Consider

- Population of the respective country;
- Weight of the CRTs: **25 kg per device** (estimated average weight of a CRT monitor, either TV or PC monitor);
- Polymer content of CRT casings: **30%**
- A range of c-OctaBDE content, **0.87-2.54 kg/tonne,** for these polymers used in CRT casings

A range of c-OctaBDE in CRT devices can be calculated as follows:

MPBDE(*i*) = [Number of CRTs/capitaRegion] x population x 25 kg x 0.3 x [0.00087 to 0.00254]

Where:

- MPBDE(i) is the amount of POP-PBDEs (i) in [kg] (in Polymer (k) of electrical and electronic equipment (EEE) (j)) The POP-PBDEs (heptaBDE and hexaBDE) in the c-OctaBDE can be calculated according to the homologue content. (of c-OctaBDE, the heptaBDE homologue is estimated as 43% and the hexaBDE as 11%).

Table Annex 2.10: Weight estimation of specific articles in categories 3 and 4 (adapted from Green Advocacy and EMPA, 2011)

Articles	**Weight (kg)**	**Source**
Category 3: Information and communication technologies		
CRT monitor	14.1	Laffely, 2007; Zumbuehl, 2006
LCD monitor	4.7	SWICO Recycling Guarantee, 2006; ecoinvent v2010
Desktop computer (incl. mouse and keyboard)	9.9	Eugster et al., 2007
Laptop computer	3.5	SWICO Recycling Guarantee, 2006;ecoinvent v2010
Mobile phone	0.1	Estimate
Telephone	1	Huisman et al., 2008
Printer	6.5	Laffely, 2007
Photocopier	52	Furniture re-use network, 2009
Category 4: Consumer electronics		
Television (CRT)	31.6	Zumbuehl, 2006
Television (LCD)	15	Estimate
Radio	2	Huisman et al., 2008
Hi-fi system	10	Huisman et al., 2008