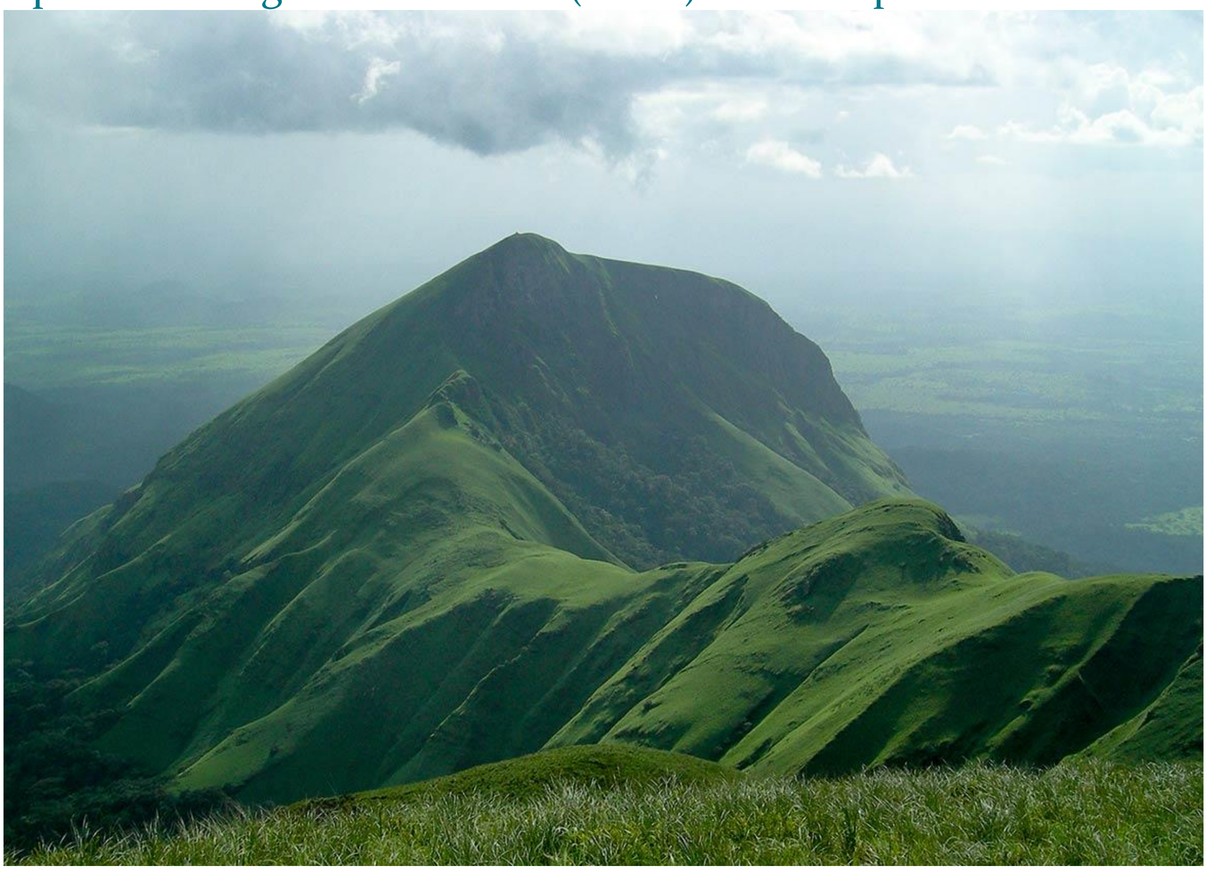
Project Name: Enabling Activities to Review and Update the national Implementation Plan the Stockholm Convention on persistent organic Pollutants (POPs) in the Republic of Liberia



FINAL DRAFT
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LIST OF ACRONYMS

AMEU	African Methodist Episcopal University
ARI	Acute Respiratory Illness
BIVAC	Bureau of Inspection Valuation Assessment and Control
BFR	Brominated flame retardant
CAS	Chemical Abstract Service
CUC	Cuttington University College
DDT	1,1,1-trichloro-2,2-bis(4-chlorophenyl)ethane; d(ichloro)d(iphenyl)t(richloroethane)
EA	Enabling Activity
EE	Electronic equipment
EEE	Electrical and electronic equipment
EIA	Environmental Impact Assessment
ELV	End of life vehicles
EPA	Environmental Protection Agency
FDA	Forestry Development Authority
FPCO	Firestone plantation Company
g	gram
GEF	Global Environment Facility
HBB	Hexabromobenzene
HCB	Hexachlorobenzene
IARC	International Agency for Research on Cancer
IGNC	Inter-Governmental Negotiating Committee
LWSC	Liberia Water and Sewer Corporation
MLME	Ministry of Land Mines and Energy
MOA	Ministry of Agriculture
MOHSW	Ministry of Health and Social Welfare

NA	Not applicable
ng	nanogram
Nm3	Normal cubic meter (Standard temperature O°C and pressure 101.3Kpa
NIP	National Implementation Plan
NGOs	Non-governmental organization
c-PentaBDEs	Commercial pentabromodiphenyl ether
PCB	Polychlorinated biphenyl
PBDE	Polybrominated diphenyl ether
PeCB	Pentachlorobenzene
PFOS	Perfluorooctane sulfonic acid
PIC	Prior Informed Consent
POPs	Persistent Organic Pollutants
PUR	Polyurethane
c-OctaBDEs	Commercial octabromodiphenyl ether
TEQ	Toxic equivalent
UN	United Nations
UNEP	United Nations Environmental Programs
UNIDO	United Nations Industrial Organization
WEEE	Waste of electrical and electronic equipment

List of Acronyms relevant to the PCDD/PCDFs Inventory

2,4,5-T	2,4,5-Trichlorophenoxyacetic acid
°C	Degrees Celsius
a	Year (annum), 365 days
ADt	Air-dried ton (of pulp)
APC(s)	Air pollution control (system)
BAT	Best available techniques
BEP	Best environmental practices
BF	Blast furnace
BOF	Basic oxygen furnace
BOS	Basic oxygen steel
C	Chlorination bleaching stage using molecular chlorine dispersed dissolved in water (pulp and paper production)
CCMS	Committee on Challenges of Modern Society
CHP	Combined heat and power
CF	Cupola furnace
CLRTAP	Convention on Long-range Transboundary Air Pollution
CNP	2,4,6-Trichlorophenyl-4’-nitrophenyl ether
CORINAIR	Core inventory of air emissions
CTMP	Chemo-thermo-mechanical pulp
CUF	Capacity Utilization Factor
D	Chlorine dioxide bleaching stage using a water solution of chlorine dioxide (ClO_2) (Section on pulp and paper production)
DCB	Dichlorobenzene
dl-PCB	dioxin-like Polychlorinated Biphenyls
DL	Detection limit
d.m.	Dry matter

E (NaOH)	Extraction bleaching stage using sodium hydroxide
EAF	Electric arc furnace
ECVM	European Council of Vinyl Manufacturers
EDC	1,2-Dichloroethane
EMEP	Co-operative Programme for Monitoring and Evaluation of the Long-Range Transmission of Air Pollutants in Europe
EPA	Environmental Protection Agency
ESP	Electrostatic precipitator
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GEF	Global Environment Facility
h	Hour(s)
H_2SO4	Sulfuric acid
ha	Hectare(s)
HCB	Hexachlorobenzene
HW	Hazardous waste
I-TEF	International Toxicity Equivalency Factor
I-TEQ	International Toxic Equivalent
IF	Induction furnace
IPCS	International Programme on Chemicals Safety (of the World Health Organization)
IPPC	Integrated Pollution Prevention and Control (of the European Union)
ISO	International Organization for Standardization
K	(Degree) Kelvin
kPa	Kilo Pascal (= one thousand Pascal)
L	Liter

LOI	Loss of ignition (a measure for residual carbon content)
LoC	Level of Confidence
LOQ	Limit of quantification
LPG	Liquefied petroleum gas
LS	Liquid steel
m	Meter
m^3	Cubic meter (typically under operating conditions without normalization to, e.g., temperature, pressure, humidity)
Mg	Magnesium but see also: megagram (under units)
MSW	Municipal solid waste
NA	Not applicable (not a relevant release vector)
NaOH	Sodium hydroxide
Na_2S	Sodium sulfide
N-TEQ	Toxic equivalent using the Nordic scheme (commonly used in the Scandinavian countries)
ND	Not determined/no data (in other words: so far, no measurements available)
NFR	Nomenclature For Reporting
NIP	National Implementation Plan (under the Stockholm Convention on Persistent Organic Pollutants)
Nm^3	Normalized (standard) cubic meter; the volume a gas occupies at atmospheric pressure (1,013 mbar) and 273.15 K (0°C)
o	ortho
O	Oxygen bleaching stage (pulp and paper production)
p	para
PCB	Polychlorinated biphenyls
PCDD	Polychlorinated dibenzo-p-dioxins
PXDD	Polyhalogenated dibenzo-p-dioxins
PCDF	Polychlorinated dibenzofurans

PXDF	Polyhalogenated dibenzofurans
PeCBz	Pentachlorobenzene
PCP	Pentachlorophenol
PCP-Na	Sodium pentachlorophenol
POPs	Persistent organic pollutants
PRTR	Pollutant Release and Transfer Register
PTS	Persistent toxic substances
PVC	Polyvinyl chloride
RDF	Refuse-derived fuel
rpm	Revolutions per minute
SCR	Selective catalytic reduction/reaction
SI	International system of units
SNAP	Selected Nomenclature for Air Pollution
t	Ton (metric)
TCB	Trichlorobenzene
TCF	Totally chlorine free (bleaching)
TEF	Toxicity Equivalency Factor
TEQ	Toxic Equivalent Note: For the purpose of the Toolkit, there is no difference if concentrations or emission factors are reported in I-TEQ or N-TEQ or WHO-TEQ (for PCDD/PCDF only)
TMP	Thermo-mechanical pulp
TRI	Toxics Release Inventory
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organization
URL	Uniform Resource Locator (the global address of documents and other resources

	on the World Wide Web)
UV	Ultra-violet
VCM	Vinyl chloride monomer
VSK	Vertical shaft kilns

UNITS

SI Units

g	gram (10^0 g)
kg	kilogram(1,000 g)
t ton	10^6 g (1,000 kg) also Mg (Megagram)
kt	kilo-ton (1,000 t); 10^9g; 10^6 kg
mg	milligram (10^{-3} g)
µg	microgram 10^{-6} g
ng	nanogram (10^{-9} g)
pg	picogram(10^{-12} g)
fg	femtogram (10^{-15} g)
kJ	Kilojoule(10^3 Joule)
MJ	Megajoule (10^6 Joule)
GJ	Gigajoule (10^9 Joule)
TJ	Terajoules (10^{12} joule)
MW	Megawatt (10^6 watt)
MWh	Megawatt hour (10^6 watt-hour)
Pa	Pascal
kPa	kilopascal (10^3 Pascal)

1. Executive Summary

This revised National Implementation Plan (NIP) for Stockholm Convention on Persistent Organic Pollutants (POPs) has been prepared by the Environmental Protection Agency (EPA) of Liberia serving as national focal point for the convention. The rationale for undertaking this initiative is to review and update the country 2006 National Implementation Plan and assess the country level of compliance with the convention given that nine (9) new chemicals have been added to the list of chemicals covered by this convention

The Stockholm Convention on Persistent Organic Pollutants POPs is a global, legally binding mechanism whose primary objective is to protect human health and the environment from the harmful effects of toxic chemicals. Liberia acceded to the Stockholm Convention in May 2002 and in fulfillment of the country's obligation under article 7 of the convention, the preparation of the country's National Implementation Plan (NIP) commenced in 2004 and was completed and validated in 2006. The developments of the NIP form the bases for a national phase-out or reduction program and eventual elimination of POPs at the local and international levels.

The mechanism employed for the update of this NIP involves hiring services of consultants who were grouped into five categories. Each group of consultant was given a specific area to conduct a survey. Accordingly, the following thematic areas assigned to each group of consultants are research on old and new unintentional POPs, research on old and new POPs pesticides, research on old and new industrial POPs, research on legal aspect and research on socio-economic assessment. Each group perused the 2006 NIP and developed a comprehensive work plan to review and update the NIP. Each consultant prepared a questionnaire with an aim at taking inventory of POPs chemicals in according to assigned areas mentioned above. Meetings of consultant to review information and data collected from field work were held. This was followed by compiling the revised NIP and subsequent presentation to stakeholders for their import which finally led to the validation this revised NIP.

2. Country background

(to be checked and updated by the national responsible officer)

Figure 1. Map of Liberia, showing locations where cross border waterways first meet Liberian territory

Liberia, the "Land of the Free" a tropical country in West Africa with a spectacular coastline at the North Atlantic Ocean. The country was known for some time as the Pepper Coast and later as the Grain Coast. It is surrounded by Sierra Leone, Guinea and Côte d'Ivoire.

Liberia covers an area of 111,369 km² (43,000 sq mi), making it somewhat larger than Bulgaria or slightly larger than the U.S. state of Tennessee.

The country has a population of about 4.5 million people (in 2015).

Capital and largest city is Monrovia, (named after, no not Marilyn Monroe, but James Monroe, the fifth President of the United States (1817–1825)). The country's major cities are located along the coast like the port cities of Harper and Buchanan.

Spoken languages are English (official) and an English-based pidgin (Liberian English), plus several indigenous languages.

Liberia is one of the poorest countries in the world with a high unemployment rate (85%) and rampant corruption at almost every level of the Liberian government. The country is recovering from a 14-year civil war where 250,000 people were killed and many thousands more fled the fighting. In 2014 the country was also affected by the worst Ebola epidemic in history.

Political system

Liberia is a unitary state and a presidential representative democratic republic with a multi-party system, modeled after the government of the United States. Head of state and head of government is the President. The cabinet is appointed by the president and confirmed by the Senate. The bicameral National Assembly consists of a Senate and a House of Representatives.

The country's legal system is a mixed system of common law (based on Anglo-American law) and customary law.

3. Stockholm Convention, brief history old and new POPs

During the 1960s and 1970s, the use of chemicals and pesticides in industry and agriculture increased dramatically. In particular, a category of chemicals known as persistent organic pollutants (POPs) attracted international attention due to a growing body of scientific evidence indicating that exposure to very low doses of POPs can lead to cancer, damage to the central and peripheral nervous systems, diseases of the immune system, reproductive disorders and interference with normal infant and child development. POPs are chemical substances that persist in the environment, bioaccumulate in living organisms, and can have adverse effects on human health and the environment. With further evidence of the long-range environmental transport (LRET) of these substances to regions where they have never been used or produced, and the consequent threats they pose to the global environment, the international community called for urgent global action to reduce and eliminate their release into the environment.

In March 1995, the United Nations Environment Programme's Governing Council (UNEP GC) adopted Decision 18/32 inviting the Inter-Organization Programme on the Sound Management of Chemicals, the Intergovernmental Forum on Chemical Safety (IFCS) and the International Programme on Chemical Safety to initiate an assessment process regarding a list of 12 POPs. The decision also invited IFCS to develop recommendations on international action on POPs. The IFCS Ad Hoc Working Group on POPs concluded that sufficient information existed to demonstrate the need for international action to minimize risks from the 12 POPs, including a global legally-binding instrument. The IFCS forwarded a recommendation to the UNEP GC and the World Health Assembly (WHA) that immediate international action be taken on these substances.

In February 1997, the UNEP GC adopted Decision 19/13C endorsing the conclusions and recommendations of the IFCS. The GC requested that UNEP, together with relevant international organizations, convene an intergovernmental negotiating committee (INC) with a mandate to develop, by the end of 2000, an international legally-binding instrument for implementing international action, beginning with the list of 12 POPs. In May 1997, the WHA endorsed the recommendations of the IFCS and requested that the World Health Organization participate actively in the negotiations.

The INC met five times between June 1998 and December 2000 to elaborate the convention, and delegates adopted the Stockholm Convention on POPs at the Conference of the Plenipotentiaries, which convened from 22-23 May 2001 in Stockholm, Sweden.

Key elements of the treaty include the provision of new and additional financial resources by developed countries and obligations for all parties to eliminate production and use of intentionally produced POPs, eliminate unintentionally produced POPs where feasible, and manage and dispose of POPs wastes in an environmentally-sound manner. Precaution is cited throughout the Convention, with specific references in the preamble, the objective and the provisions on identifying new POPs. The Convention can list chemicals in three annexes: Annex A contains chemicals to be eliminated; Annex B contains chemicals to be restricted; and Annex C calls for the minimization of unintentional releases of listed chemicals. When adopted in 2001, 12 POPs were listed in these annexes. These POPs include 1) pesticides: aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, mirex and toxaphene; 2) industrial chemicals: hexachlorobenzene and polychlorinated biphenyls (PCBs); and 3) unintentionally produced POPs: dioxins and furans.

The Stockholm Convention entered into force on 17 May 2004 and currently has 179 parties.

When adopting the Convention, provision was made for a procedure to identify and list additional POPs. At the first meeting of the Conference of the Parties (COP-1), held in Punta del Este, Uruguay, from 2-6 May 2005, the POPs Review Committee (POPRC) was established to consider additional candidates nominated for listing under the Convention.

In June 1998, an Inter-Governmental Negotiating Committee (INC) converged in the City of Montreal, Canada to prepare an internationally binding document for the implementation of an international action that gave birth to the Stockholm Convention. The final documentation of the agreement was concluded in Johannesburg, South Africa in 2000 with the establishment of an expert group to develop criteria and a procedure for identifying additional POPs as candidates for future international action as well as a number of immediate actions to address POPs.

The Stockholm Convention on Persistent Organic Pollutants (POPs) was adopted and opened for signature at a Conference of Plenipotentiaries held from 22 to 23 May 2001 in Stockholm, Sweden. Ninety-two (92) States and the European Community signed the Convention at a ceremony in Stockholm on 23 May 2001. The Stockholm Convention entered into force on 17 May 2004, 90 days after the submission of the fiftieth instrument of ratification.

The objective of the Stockholm Convention is to protect human health and the environment from persistent organic pollutants. This is consistent with the precautionary approach set forth in Principle 15 of the Rio Declaration on Environment and Development

Liberia acceded to the Stockholm Convention in May 23, 2002 and in fulfillment of the country's obligation under Article 7 of the convention, preparation of the National Implementation Plan kicked off in 2004 and completed in 2006 following series of POPs National Steering Committee (PNC) meetings, enabling activities meetings, stakeholders meetings, inception/training workshops and national priority validation workshop. Liberia succeeded in completing the formulation the National Implementation Plan through the support of the enabling activity grant from the Global Environmental Facility (GEF) and technical support from the United Nations Industrial Organization (UNIDO).

The preparation of the 2006 NIP followed the guidance issued by the Stockholm Convention and GEF, and efficiently covered Liberia's current situation then, with respect to the presence and release of POPs in the country, the status of compliance relative to each provision of the Convention, and the national response adopted in the near and long term to the issue in the form of an Action Plan.

At its third and fourth Conference of Parties (COP) meetings, the POPs Review Committee, POPRC, recommended the nine new POPs to be considered and listed in Annexes A, B and/or C of the Stockholm Convention.

During the fourth Conference of the Parties (COP4) to the Stockholm Convention on Persistent Organic Pollutants (POPs) held from 4-8 May 2009, in Geneva, Switzerland, the Parties of the Stockholm Convention adopted amendments to Annexes A, B and C to list nine additional chemicals, out of which five POPs pesticides and four industrial POPs.

The five POPs pesticides are:

1. alpha hexachlorocyclohexane;
2. beta hexachlorocyclohexane;
3. chlordecone;

4. lindane;

5. pentachlorobenzene;

The four industrial POPs are:

6. tetrabromodiphenyl ether and pentabromodiphenyl ether.

7. hexabromodiphenyl ether and heptabromodiphenyl ether;

8. hexabromobiphenyl;

9. perfluorooctane sulfonic acid, its salts and perfluorooctane sulfonyl fluoride;

When chemicals are added to the Convention, Parties must review their NIP and update it with information on how they will address the newly listed POPs. The process of reviewing and updating the NIPs can be challenging for Parties that lack adequate resources and technical capacity. Parties have expressed the need for assistance in that regard and in particular in obtaining information on the presence of new POPs that are widely used for industrial purposes and are contained in articles.

To assist Parties in updating their national implementation plans to address the new POPs, a set of guidance documents has been developed by the United Nations Industrial Development Organization (UNIDO) and the United Nations Institute for Training and Research (UNITAR), working in collaboration with the Secretariat of the Stockholm Convention (SSC). These documents aim at supporting Parties in developing strategies to restrict and eliminate the new POPs, by providing guidance on establishing inventories, monitoring the presence of products and articles containing new POPs, and selecting best available techniques and best environmental practices for situations when production, use, and recycling of industrial POPs are allowed by the Convention.

Basic Outline of the Stockholm's Convention applicability to Liberia

Liberia has never been a producer of chemicals defined by the Convention as POPs. Notwithstanding, POPs are imported into the country under different trade names or are imported as components contained in other products or equipment. It is also evident that there are sources of unintentional POPs release and POPs legacies in the form of stockpiles, waste and contaminated sites.

Liberia's commitment to the Stockholm Convention on POPs is predicate upon the fact that those chemicals of concern have the ability to surface in areas where they are not produced or used. Furthermore, conventional agricultural methods in Liberia a wide range of agricultural chemicals to improve |the yield and quality of produce and to control weeds, insect pests and disease

Liberia is also a party to the Basel Convention on the Control of Transboundary Movements on Hazardous Waste and their Disposal and is obliged to find environmentally sound solutions for all POPs chemicals as wastes. Similarly, Liberia has ratified The Rotterdam Convention on the Prior Informed Consent (PIC) Procedure for Certain Hazardous Chemicals and Pesticides in International Trade which became international law and thus legally binding on its members today. The currently recommended pesticides used in Liberia are less toxic and less persistent as compare to POPs pesticides. The stocks of outdated POP pesticides in Liberia are either negligible or non-existent and hence the issue of disposal is not a serious problem. However, larger stocks of outdated POPs containing equipment need further investigation. Although DDT has been prohibited from use in agricultural activities and from public health, it is highly suspected that this chemical is being used in the country either for the purpose of vector control or other uses. It may be imported into the country under different trade name as sometimes chemicals are sold with identified label.

There is limited information available on the residues of these chemicals in groundwater and surface water bodies because the country lacks the capacity to determine these residues in soil, groundwater and surface water. However, awareness on POP pesticide related issues is high in the urban areas due to series of awareness workshop/training being carried out under the auspices of EPA as the country's focal point of the Stockholm Convention. Replacement of the POP pesticides with other chemical alternatives in agriculture, public health vector control, industrial uses such as wood preservation and termite control have been successfully implemented in the Republic of Liberia.

Knowledge on Persistent Organic Pollutants (Old and New)

Persistent organic pollutants (POPs) are synthetic (man-made) chemicals that have similar physical, chemical, biological and toxicological characteristics. They are substances that produce adverse effects on both the ecosystem and human health due to: i) their very high toxicity; ii) their prolonged persistence in contaminated ecosystems and in individuals because of their extremely limited biodegradability and iii) their deep penetration in even the remotest areas.

Exposure to these chemicals can lead to cancer, damage to the central and peripheral nervous system, disease of the immune system. Teratogenic studies revealed that these chemicals can affect the unborn young of a vertebrate after developing to its basic form. Reproductive disorder is also associated with exposure to these chemicals.

They are persistent in the air, resist degradation, bioaccumulate and are transported through long distances. This group of chemicals has the potential to build up in areas that are very far from where they are manufacture or used. They persist in the environment for a long time, being also able of long-range transport bioaccumulate in food chain and human and animal tissue, biomagnify in food chain and to have potential significant impacts on human health and environment, being toxic to human and/or wildlife.

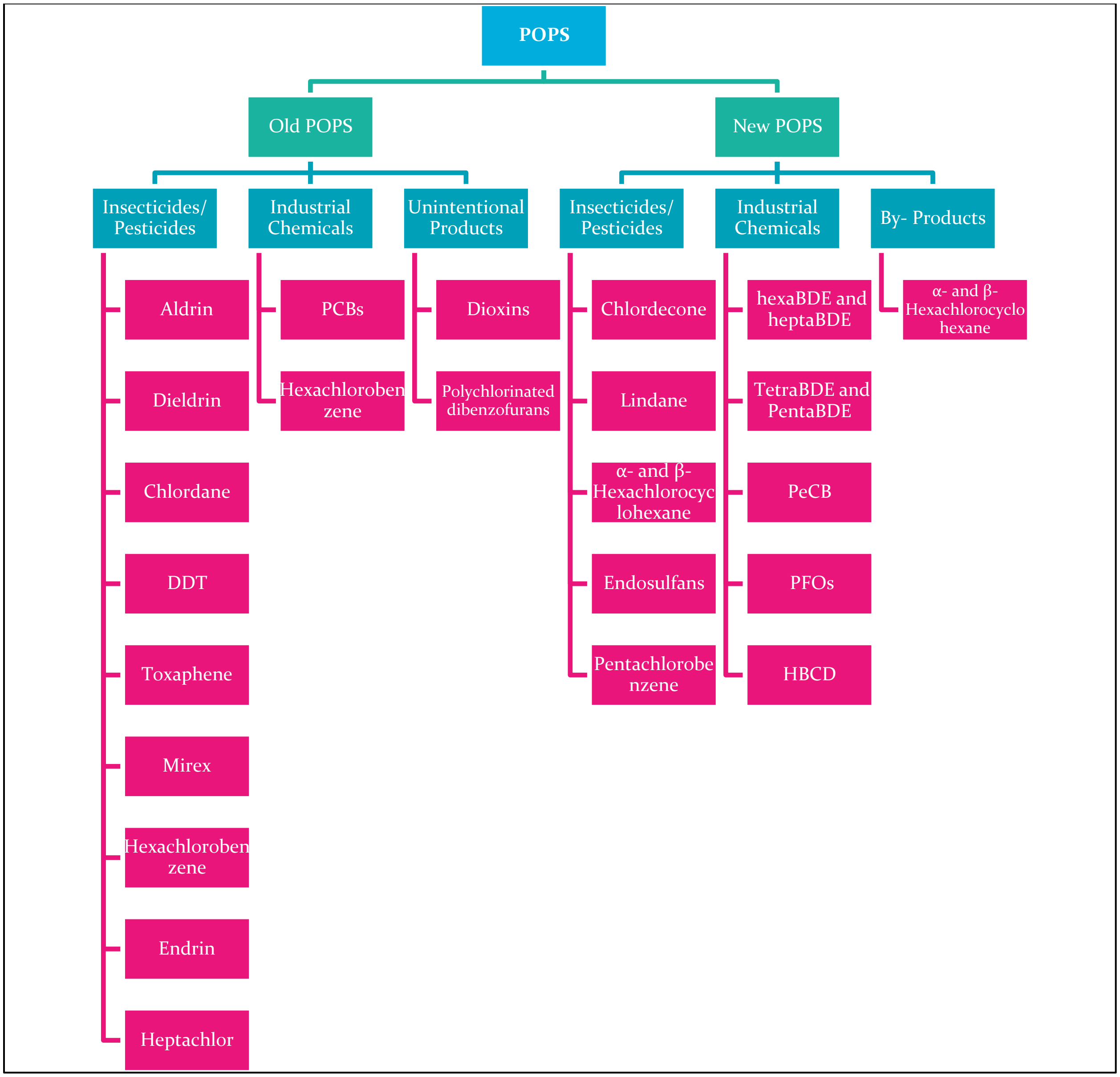
These chemicals are found in many materials that form part of human daily use. The improper management of these materials during their life span can lead to their emission and accumulation in human body, animals and the environment.

It is very likely that the main reason why organochlorine residues, such as DDT, continue to persist in the environment and even to increase is that the worldwide use of many of these products is more widespread now than in the past when they were banned in the United States due to their severe impact on human health and ecosystems.

Among the persistent organic pollutants, special attention must be given to dioxin-like compounds. These substances do not exist in nature and are not intentionally produced by man but are the result of activities such as the manufacture of other substances, the incineration of the waste produced by cities, hospitals, and industry; toxic waste; the combustion of petroleum derivatives, etc. Due to their severe toxic effects, these substances constitute a very high risk, particularly for those who live or work near where they are produced or ultimately concentrate, and such places may be as far removed from where they are emitted.

A large gray area exists in terms of knowledge on Persistent Organic Pollutants. A survey of security staff working at the port and border posts indicates that only two out of five security personnel interviewed could name any of the 24 POPs while only one could say that he thinks that the materials on the list "looked like they had problems." Of importance is the fact that of the two POPS recognized by security staff, one is unintentionally produced.

Figure 2: POPs old and new



Issues hindering enforcement of Stockholm convention

Liberia's industrial development was brutally interrupted by the civil crisis. Remaining industries are largely confined to beverage manufacture, rubber processing, ore export and production of materials used in construction. The materials made locally for use in construction are primarily bulk adding industries, including paint making and cement production. A small sector exists which produces foam products. Much more contact exists with materials which might have potentially been made through use of POPs and with POPs themselves through imports of fertilizers, pesticides and machinery.

The situation is similarly uncertain among industrial workers. The five industries queried indicated that they did not know these chemicals and did not import them. However, with Liberia not yet applying the Global Harmonized System for naming chemicals in trade, it cannot be a certainty that POPS may not inadvertently be imported, despite their desires to have it otherwise. A sentiment was observed of willingness to import only legally acceptable materials, but again the absence of a national standards laboratory means that it is not possible to determine whether the raw material used in a particular industrial process has not been adulterated with POPs or produced using a substance named in the Stockholm Convention.

Liberia is a country with very limited industrial build-up, corresponding to an equally limited production of intentional POPS. However, there is substantial risk of possible contamination through unintentional production, end of life management of industrial and agricultural materials and erratic disposal of waste of all forms. Moreover, cross-border trade and the sharing of waterways mean that it is possible that leachate containing pesticides, fertilizers or industrial POPs could leak from a neighboring country to Liberia. Liberia is now a part of the West African Power Pool. As this is an international electricity generation and transmission scheme, Liberia's own zero-tolerance to POPs in transmission devices need to be applied to all electrical equipment passing through the country,

Liberia imports all of its mechanical, electronic, transport and other equipment, making the nation particularly vulnerable to lack of compliance higher up the production pathway. Consequently, a major concern is the drawdown of humanitarian organizations, many of whom have immunity from the national laws. With their large stockpiles of electronic and electrical equipment, cars and wiring, they constitute a serious administrative dilemma, since they are not obligated to apply regulations even if they were proposed today.

Unintentional production of POPS occurs due to both the lack of practicality and poor enforcement of regulations. In the capital Monrovia, these regulations completely bar backyard burning without regard to content of the garbage, but there are no corresponding provisions outside the capital. Nevertheless, municipal authorities in the capital lack the resources to police open waste burning and have not come up with a listing of materials whose burning is not desirable.

Solid waste disposal seems poorly thought out, with the Stockton Creek transferal site located perilously close to a waterway and populated areas with over 800,000 persons in an 8 mile radius.

Impact of trade with countries which have applied for exemptions

Liberia has not applied for any exception or exemption regarding the Stockholm Convention. However, trade in manufactured products is primarily influenced by availability of the product at a particular source, competitiveness of price and quality. It is recommended that an additional criterion, the possibility that the material was made in a process that involved POPs also be taken into account. Such a decision is better taken at the national level as compared to the level of an individual establishment, since local companies may not have ready access to the information required to inform such a decision.

Role of Best Available Techniques and Best Environmental Practices

Liberia has joined other nations around the word in exploring Best Available Techniques and Best Environmental Practices for responding to the issue of POPs. Best Available Techniques have been defined as "the most effective and advanced stage in the development of activities and their methods of operation which indicate the practical suitability of particular techniques for providing in principle the basis of release limitations designed to prevent or where this is not practicable, generally to reduce release of chemicals listed in Part I of Annex C and their impact on the environment as a whole." In addition, Best Environmental Practices mean "the application of the most appropriate combination of environmental control measures and strategies."

BAT/BEP is particularly applicable to Liberia since Annex C chemicals result from unintentional production and constitute the most significant component of Liberia's current exposure to POPs. Moreover, regional efforts are being exerted to create a community of change tapping into the collective experts of people working on that field in our particular geographical landscape like in other parts of the world. The Regional BAT/BET Forum for West Africa was established on October 8, 2011 with Liberia as a member. By 2012 September, this grouping was enlarged by 14th Session of the African Ministerial Conference on the Environment, through integration with sister bodies in the Southern Africa Development Community and the Common Market for Eastern and Southern Africa to form the Regional BAT/BEP Forum for Africa[1].

The Regional BAT/BEP priorities are:

1. Open burning of wastes and landfills
2. Waste Incineration
3. Fossil fuel-fired utilities and industrial boilers
4. Metallurgical industry

Of these, particular efforts are required for items 1 and 3, which have to deal with open burning of wastes and landfills on one hand and fossil fuel fired utility/industrial boilers. Uncontrolled open burning still happens in Liberia, due partly to municipal authorities' lack of resources to effectively enforce waste disposal regulations. Additionally, all power generated for sale on the public electric grid comes from thermal plants fired by fossil fuel, in this case, heavy fuel generators. Moreover, numerous private individuals produce electricity for their own consumption and sale through the use of gasoline and diesel-fired power generators. This situation will remain of high intensity, until the restoration of hydroelectric power through the repair of the Mount Coffee Power Plant and full national integration into the West African Power Pool which will provide electricity generated from hydroelectric power in Ivory Coast to neighboring countries with limited power production, including Liberia, Guinea and Sierra Leone and also constitute a mechanism for cross border sale of excess power produced by any of these countries in the future.

Liberia in the past had no waste incineration plants. Recently, several high voltage incinerators were brought in to take care of the Ebola virus. Also 12 state of the art incinerators were imported into the country by UNICEF for medical waste incineration.

It is prudent to note that with climatic conditions meaning that much waste generated is either wet or becomes so soon after contact with the environment, factors which might reduce the viability of waste incineration as an integral part of the waste management strategy.

However, the economic status of Liberia as a mineral rich ore-exporting nation indicates that there is a possibility for growth in the metallurgical sector, particularly as power generation grows. Currently, metallurgical work going on in Liberia is largely artisanal and restricted to the production of jewelry by gold and silversmiths on one hand and that of kitchen utensils and farm implements by blacksmiths on the other. In neighboring Ivory Coast and nations elsewhere,

[1](Stockholm Convention Unit)

hydroelectric power has proven very useful in ore smelting, including the reduction of bauxite to alumina.

4. Overview of Institutional Policy- Institutional Roles and responsibilities

The following ministries and agency deal with various aspects of the regulatory framework that would enable Liberia abide by its obligations on the Stockholm Conventions on Persistent Organic Pollutants.

A number of state structures, research institutions and non-governmental organizations are involved in the management of POPs and related activities. They include the following:

Environmental Protection Agency (EPA)

Principal authority for the management of the environment, and mandated to coordinate, monitor, supervise and consult with relevant stakeholders on all activities in the protection of the environment and sustainable use of natural resources; promotes environmental awareness and the implementation of the national environmental policy and the environmental protection and management law; oversees the implementation of international environment related conventions.

The Environmental Protection Agency Act of 2003 (EPA Act) authorized the establishment of an overall institutional framework for sustainable management of the environment in Liberia, including creation of:

- National Environmental Policy Council
- Environmental Protection Agency (established)
- Board of Directors (established)
- Executive Director (established)
- Environmental Units in Line Ministries (at the time of the writing of this National Situation Report about 18 EUs had been established)
- Decentralized Environmental Committees
- County Environment Committees (not yet established)
- District Environment Committees (not yet established)
- Environmental Courts (not yet established)
- Environmental Inspectors
- Environmental Administrative Court (not yet established)
- Environmental Court of Appeals (not yet established)
- Environmental Funds (not yet established)
- National Environmental Fund (not yet established)
- Trust Fund (not yet established)

Forestry Development Authority (FDA)

The FDA is responsible to sustainably manage the forest and its related resources. The agency provides long and medium-range planning in the forest sector as well as preparing forestry policy, law and administration; supervises forest legislations and concession agreements; calculates and determines forestry fees; evaluates investment proposals; executes reforestation and forest research and training, monitors activities of timber companies, executes protected area programs and administers wildlife and national parks.

Ministry of Agriculture (MOA)

This Ministry determines acceptable and prohibited pesticides and fertilizers for use in Liberia, giving it strategic importance in responding to plans for POPs in the agricultural sector, executes, administers, manages and supervises agriculture programs and provides extension services; trains local farmers in improved cultural practices, and supplies to farms inputs to enhance food security.

Ministry of Land, Mines and Energy (MLME)

This Ministry has the statutory responsibility for the development of mineral, water and energy resources of the country and the administration of its lands; is in charge of land surveys in all parts of the country; coordinates the activities of miners of gold and diamonds, including granting of operation licenses; regulates beach sand mining and works along with the Ministry of Agriculture and the University of Liberia to conduct training research on land rehabilitation.

Ministry of Agriculture (MOA)/ Division of Agrochemicals,

The Ministry through its Division of Agrochemicals, regulates and approves the use of farm chemicals and pesticides.

Ministry of Commerce and Industry (MOCI)

The Ministry of Commerce and Industry, through its Division of Foreign Trade, regulates and approves the domestic and foreign trade in all commodities. Its EPD and IPD documents list Persistent Organic Pollutants in Group 5: CHEMICALS (using the Standard International Trade Classification of the United Nations (SITC).

Ministry of Health and Social Welfare (MHSW)

The Ministry of Health coordinates and administers the general health services of the Country; ensures the availability of drugs; collects health statistics and monitors events and conditions affecting the general public. The Ministry is in charge of preventive and curative services and vital statistics for the registration of births and deaths. The Ministry through its Division of Environmental and Occupational Health regulates and approves appropriate health responses and preventive measures, including those related to the release of or coming in contact with persistent organic pollutants.

Liberia Revenue Authority

The Liberia Revenue Authority, formerly Department of Revenue at the Ministry of Finance records entry of goods into and outside of the country for the purpose of exacting revenue through taxes and would therefore be a contact if anyone or entity were to attempt the importation of POPS into Liberia. Similarly, through its assessing of corporate revenue and profits for similar taxing purposes, it would be engaged where there is intentional local production of POPs for a corporate purpose or usage within such a setting.

Bureau of Maritime Affairs/Liberia Maritime Authority

This agency is in charge of Liberia's maritime program, with much of its work directed at the ship registry. It is also given statutory mandate over all shorelines and coastlines of Liberia. It is financially autonomous.

Monrovia City Corporation

Monrovia City Corporation was first created as a Commonwealth District in 1833 by the Commonwealth of Liberia. A legislative Act of 1973 abolished the Commonwealth District and created the Monrovia City Corporation, giving it all municipal rights, power and authorities, including enforcement of city ordinances, management of municipal wastes, recreation, public education and awareness and provision of services in environmental health and sanitation.

The city corporation manages Liberia's biggest industrial area, busiest port and capital, Monrovia. According to the last national census (2008), Monrovia is more than 20 times larger in population than the next largest city.

Liberia Water and Sewer Corporation (LWSC)

Responsible to plan, execute, administer, manage and supervise the generation and distribution of water to the public. It is also responsible for the supply of safe drinking water, provides service concerning the sanitary disposal of waste and maintains the water sewage facilities. The corporation produces, transmits and distributes pipe-borne water. The corporation rehabilitates water and sewer facilities throughout Liberia and improves and expands services to meet the water needs of all residents.

Liberia Electricity Corporation (LEC)

LEC was created by an Act of the National Legislative in 1973 with the mandate to generate, transmit, distribute and sell electricity at an economically reasonable tariff throughout the length and breadth of the country; plans, executes, administers, manages, and supervises the generation and distribution of electricity.

Liberia Petroleum Refining Corporation (LPRC)

The LPRC plans, executes, administers, manages and processes crude oil into finished petroleum products for the Liberian market and also ensures that petroleum products are readily available.

Center for Environmental Education and Protection (CEEP)

Center for Environmental Education and Protection of Liberia (CEEP) has the mission to contribute to poverty reduction through environmental education and public awareness. The organization usually lobbies and advocates for sustainable development. CEEP has been engaged in teaching principals and concepts of environment in school and the communities through workshops and seminars.

Environmental Relief and Development Research Organization (ERADRO)

Environmental Relief and Development Research Organization (ERADRO) is involved with the promotion of extension services in the field of environmental research, social mobilization, animation of health/hygiene education, solid/domestic waste programs in schools and communities.

Pollution Control Association of Liberia (POCAL)

This association advocates proper waste management, organizes nature clubs in schools and supports environmental drama clubs in communities; it established a botanical garden in Johnsonville, Montserrado County, where integrated pest management is being taught. It also conducts a public awareness program on POPs.

Liberia Indigenous Forum for the Environment (LIFE)

The Liberia Indigenous Forum for the Environment strives to work with local communities to bring about awareness and empowerment on matters of environmental and conservation concerns. One of its major thrusts is to ensure that traditional knowledge is respected and maintained in Liberia. It propagates conservation of biodiversity, especially of medical plants. LIFE has been concerned about the state of timber operations, especially the fate of some timber species thought to be threatened or vulnerable.

Association of Environmental Lawyers (GREEN ADVOCATES), INC. (AEL)

Established in December 2000 by a group of lawyers, it strives to create and maintain a multi-disciplinary environment team. Green Advocates Team on the Environment (GATE), comprises not only lawyers but also professionals with science, engineering and other career backgrounds, critical to the accomplishment of the group's mission of protecting the environment through law; it advocates appropriate environmental protection legislation and pursues court action to compel compliance with and enforcement of current environmental laws.

Enviro-link Liberia,Ltd

This organization links people and communities to the environment through advocacy, awareness, education, training and research; involved in environmental impact assessments in collaboration with the EPA and other environmental institutions.

University of Liberia (UL)

The University of Liberia attracts and trains many hard-core professionals in the colleges of science and technology, agriculture and forestry, and business and public administration. The College of Science and Technology offers bachelor's degrees in biology, zoology, engineering, chemistry, geology, physics and mathematics. The College of Environmental Science is in the making.

Cuttington University College (CUC)

The Cuttington University College in Central Liberia offers bachelor's degrees in general science, biology, chemistry, physics and mathematics. Other relevant courses offered in the area of biodiversity are agriculture and rural development.

Liberia Agriculture Company (LAC)

LAC operates a rubber plantation in Grand Bassa County; developed pasturelands and once dealt in raising cattle; develops rubber clones for its own use.

Firestone Plantations Company

Established in 1926, operates the world's single largest rubber plantation at Harbel in Margibi County; established a nursery for rubber clones and was once involved in botanical research; owns and operates the largest private hydroelectric plant in the country.

The administrative agencies mentioned above promulgate from time to time appropriate regulations pursuant to the statutes for which they are responsible.

4.1 Environmental Policy and General Regulatory Framework

The EPA Act

The Act creating the EPA now requires environmental impact assessment (EIA) of all activities, decisions, programs, projects and policies, which may have significant impacts – beneficially and adversely – on human health and the environment. This has been applied to concessions having mining and commercial agricultural interests, and even the power transmission network of the West African Power Pool.

The National Environmental Policy of Liberia

The National Environmental Policy of Liberia provides a broad framework for the proper and responsible management of natural resources and the protection of human health and the environment. The policy goal of NEP is to ensure long-term economic prosperity of Liberia through sustainable social and economic development, which enhances environmental quality and resource productivity on a long-term basis that meets the requirements of the present generation without endangering the potential of future generations to meet their own needs. Specifically, the NEP states that the Government of Liberia will:

- Commit itself to the sound scientific and sustainable use of natural resources
- Create environment awareness among all sections of the community
- Develop procedures for the utilization of land resources so as to ensure the maximum degree of economic value
- Require prior environmental impact assessments for all investments that may impact the environment
- Institute appropriate measures to control pollution and the importation and use of potentially toxic chemicals
- Take appropriate measures to protect critical ecosystems against harmful effects, or destructive practices
- Develop and maintain a professional agency to supervise, coordinate, implement and enforce procedures and legislation essential for safeguarding the environment
- Oblige all concerned to provide the relevant information needed for environmental protection and for the enforcement of environmental regulations and legislation
- Promote and support environmental research programs
- Establish an adequate legislative and institutional framework for monitoring, coordinating and enforcing environmental programs and issues.

The NEP states that these commitments will be accomplished by the harmonization and enforcement of Environmental Protection and Management Law (EPML). It also directs all ministries and agencies of the Government to review their statutory authority, administrative regulations and current policies and procedures and correct any deficiencies or inconsistencies with the policy. The policy specifically calls for the creation of the Environmental Protection Agency (EPA) as an independent authority for the management of the environment. It also calls for the adoption of the Environmental Protection and Management Law as a tool for implementation of the NEP, and states that the law should provide for:

- Improved access to information on the environment:
- Harmonization of the appropriate legal instruments
- Monitoring and evaluating the impact of policy decisions on the environment
- Improvement of the scientific base of environmental decisions through appropriate research programs
- Assessment of potential impacts of public and private projects on the environment, and environmental mainstreaming into the national planning process
- Establishment and implementation of appropriate standards and guidelines so as to ensure an acceptable level of public health and environmental protection.

The bulk of the NEP (Sections 3.0 through 6.1 encompassing 24 pages of the 38 page document) contains recommendations for incorporating environmental concerns into various facets of development ranging from development of human settlements to the involvement of youth and women in environmental protection. This section of the NEP, however, contains only recommendations for actions in each of these areas. As such, it is not binding on any institution or activity.

Among the recommendations for action, there are a number that have a bearing on issues regarding persistent organic pollutants, these are:

- Occupational Health and Safety
- Environmental Impact Assessment (EIA)
- Environmental Information
- Energy Production and Use
- Toxic and Hazardous Substances
- Agricultural/Forestry Chemicals
- Waste Management & Sanitation
- Mining and Mineral Resources
- Noise and Air Pollution
- Capacity Building and Technology Transfer
- Public Education & Awareness

The Environmental Protection and Management Law

Part IV of the Environmental Protection and Management Law (EPML) provides for the establishment of standards by the EPA, in consultation with relevant line administrative agencies, regarding water and air quality, POPs, other toxic chemicals and pesticides (including hazardous wastes and materials), waste management, soil quality as well as noise pollution, noxious odors, ionization and radiation.

The Law stresses intersectoral coordination and authorizes EPA, in consultation with the relevant Line Ministries, agencies and/or authorities, to promulgate several procedures, measures, guidelines, plans, registries, criteria, licenses/permits, standards and regulations to protect the environment.

Part I*: P*resents the title and short title of the Law as well at the definitions of terms used in the Law.

Part II*: C*ontains the general principles and objectives under which the EPML is to be administered.

These include:

- The principle of sustainable development
- The pre-cautionary principle
- The polluter-pays principle
- The principle of inter-generational equity
- The principle of public participation
- The principle of international cooperation in the management of environmental resources shared by two or more states

In addition to these basic principles, the EPML directs that the Law be implemented so as to:

- Facilitate the restoration, protection, and conservation of biological diversity
- Ensure respect, preservation, promotion and management of historic, cultural and spiritual resources
- Comply with international environmental treaties that Liberia has ratified
- Enable and encourage environmental education and awareness

Part II also contains Section 5, which grants the right to a clean and healthy environment to the people of Liberia and establishes legal procedures for securing those rights.

Part III: Contains detailed procedures for the implementation of an Environmental Impact Assessment (EIA) program for Liberia. This Part, along with Annex I that pertains to Part III, takes up a full one quarter of the text of the Law and provides enough detail and specific legislative language for EPA to implementation of an EIA program with minimal subsequent development of procedures.

The proposed EIA process (UNDP, 2012)[2]:

- Provides for a transparent participatory approach that allows all stakeholders to have input into and be informed of all decisions that will lead to activities that are likely to have a negative effect on their health and communities
- Is intended to provide a balance between environmental, economic, social and cultural values for sustainable development of the country

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[2] http://mirror.undp.org/liberia/protect.htm

- Requires an assessment of the impact of projects, activities and policies and plans likely to lead to projects and activities that will or are likely to degrade the environment. See Annex I for matters requiring an EIA
- Identify the anticipated impacts of a proposed policy, project or activity--both adverse and beneficial impacts, and predict the extent and scale of the impact
- Determine whether the adverse impacts can be mitigated
- Recommend preventive and/or mitigation measures including alternatives
- Identify a monitoring and evaluation plan
- Recommends whether or not the proposed policy or project should be implemented or modified

Part IV**:** Concerns the establishment of environmental quality standards. The Law requires EPA, in consultation with relevant Line Ministries, to establish a national environmental quality monitoring system. It also requires that the EPA work with relevant Line Ministries to establish environmental quality standards and/or guidelines for:

- Water Quality
    - Ambient Standards
    - Use Standards
    - Effluent Standards
- Air Quality
    - Ambient Standards
    - Occupational Standards
    - Emissions Standards
- Hazardous Wastes and Materials
    - Classification System
    - Guidelines for Handling, Storage, Transport, and Disposal
- Solid Waste Management Guidelines
- Soil Quality
    - Standards
    - Management Guidelines
- Noise and Vibration Standards and Guidelines
- Ionization and other Radiation Standards
- Noxious Odors Standards
- Other Environmental Standards for:
    - Labor and Work Places
    - Industrial Products

    - Materials Used in Industry, Agriculture and for Domestic Uses;
    - Consumer Products
- Guidelines for Environmental Disasters

In addition to requiring the promulgation of standards and guidelines, many of these sections also include provisions for implementing a management or regulatory program for implementing those standards or guidelines.

Part V: Covers pollution control and licensing. This part, in conjunction with many of the requirements in Part IV, provides for the development of programs to manage:

- Pesticides
- Toxic and Hazardous Materials
- Leaded Gasoline and Paint
- Hazardous Waste
- Wastewater Effluents
- Solid Waste Management
- Air Pollution

Parts VI and VII: Authorize programs to manage natural resources and biodiversity. These parts include requirements for the establishment of programs to protect and sustainably manage rivers, lakes, wetlands, coastal zones, marine environments, forests, natural heritage sites wildlife, and genetic resources. Also included in these parts are programs for land use planning, energy management, and *protection of the ozone layer*.

All of the programs identified in these parts require consultation with the relevant Line Ministry. However, the wording is always that the "*Agency shall promulgate*", leaving some confusion as to who should take the lead for some activities such as management of forests and protected areas and *pesticide management* where other government agencies (the FDA and the Ministry of Agriculture respectively) have been given responsibility by their authorizing laws.

Parts VIII, IX and XII : Deal with enforcement of the requirements of the EPML, including Restoration Orders, the roles and responsibilities of Environmental Inspectors and offences of the requirements of the EPML. Part IX also includes requirements for the designation of analytical and reference laboratories to conduct the analyses necessary for enforcement of the Law.

The remaining parts of the EPML deal with international and regional environmental treaties, conventions, and agreements (Part X), environmental education and awareness (Part XI), and miscellaneous provisions (Part XII). One of the miscellaneous provisions charges EPA to recommend to the legislature regulations that are "*required or permitted*" by the EPML. This provision is somewhat confusing, in that Law repeatedly states that EPA shall promulgate regulations, guidelines, procedures, measures, standards and licenses.

Generally, in Liberia, regulations are initiated by a technical Line Ministry or agency and Ministers or Heads of agencies can sign regulations into law. UNEP‘s 2007 review of Liberia‘s environmental policies, acts and laws concluded that: "*It is not clear whether these references to the Legislature in the context of subordinate legislation are erroneous, although it appears they may be. If they are, legislative amendment will be required. However, it is the view of UNEP-PCDMB that* *references to the Legislature as subordinate law-maker do not preclude the EPA from having subordinate law-making powers under the EPA Act and EPM Law is supported. The view is bolstered by precedent and accepted practice in Liberia, and by the evidence of the drafters' intention in specific and mandatory regulation-making obligations imposed on the EPA in relation to certain sectoral areas under the EPM Law*".

A POPs Regulatory Regime

Liberia does not have domestic law on chemicals however, it is part of international treaties on POPs and therefore has the obligations to apply various session related to protecting the environment from pollutions.

The Convention on POPs urges parties to be "conscious of the need for global action on persistent organic pollutants".

Moreover, Liberia's Environmental and Municipalities laws cover the issue of waste management but in general. Laws that are established in Liberia are the acts establishing the EPA and MCC of which EPA coordinates meetings on chemicals while MCC carries out activities on waste management. It is therefore necessary to create laws (regulations) that specifically focus on chemicals and waste in Liberia.

There is currently no domestic legislation specifically regulating the use of POPs pesticides in Liberia, but a broad national legal and institutional framework exists for the issuance of such regulations and their enforcement.

5. Relevant International Agreements and Commitments

An opportunity for a domestic regulatory regime presently exists, because Liberia is a signatory not only to the POPs Convention but also to a number of other similar international legal instruments, including the Rotterdam Convention on the Prior Informed Consent (PIC) Procedure for Certain Hazardous Chemicals and Pesticides in International Trade, and the Basel Convention on Trans-boundary Movement of Hazardous Substances.

Together with other states, the Republic of Liberia adopted Agenda 21 and the Rio Declaration at the United Nations Conference on Environment and Development (Rio de Janeiro, 3-14 June 1992), and the Johannesburg Declaration on Sustainable Development and Recommendation for Submission to the UN Assembly at the World Summit on Sustainable Development (Johannesburg, 2002). The Republic of Liberia has signed and ratified a number of Conventions and Agreements relating to the environment. The EPA is the officially assigned National Focal Point responsible for international agreements on various environmental and management issues of Persistent Organic Pollutants. A list of related international agreements to which Liberia is a Party and ratification dates are provided in Annex I.

Table 1: International Agreements relevant to POPs to which Liberia is a party.

Name	Adoption Date	Ratification Date	Objectives
The Vienna Convention on Protection of Ozone Layer and Montreal Protocol on		January 15, 1996	Protect human health and the environment against adverse effects resulting from modifications of the

Substances that Deplete the Ozone Layer			ozone layer from anthropogenic emissions of substances proved scientifically to have high ozone depleting potential
The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal	Entered into force May 5, 1992	September 22, 2004	1. To reduce trans- boundary movements of hazardous and other wastes to a minimum consistent to their environmentally sound management 2. To treat hazardous wastes and other wastes 3. To minimize the generation of hazardous wastes
The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal	Entered into force May 5, 1992	September 22, 2004	1. To reduce trans- boundary movements of hazardous and other wastes to a minimum consistent to their environmentally sound management 2. To treat hazardous wastes and other wastes 3. To minimize the generation of hazardous wastes
Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade	Acceded August 20, 2002		
Bamako Convention on the ban of the import into Africa and the control of trans-boundary movements of hazardous wastes within Africa (Bamako convention)	January 30, 1991	September 16, 2005	1. To protect by strict control the human health of African population against adverse effects which may result from hazardous waste by reducing their generation to a minimum in terms of quantity and or hazard potential 2. To adopt precautionary measures ensure proper disposal of hazardous waste and to prevent dumping of hazardous wastes in Africa.
Stockholm Convention on Persistent Organic Pollutants (POPs)		Acceded January 16, 2002	1. To strengthen National Capacity and to enhance knowledge and understanding Amongst decision makers, managers, industry and the public at large on POPs

			2. To develop a National implementation Plan (NIP) to manage the elimination of POPs.
Strategic Approach to International Chemicals Management (SAICM)	2006		Achievement of the sound management of chemicals throughout their life cycle so that, by 2020, chemicals are produced and used in ways that minimize significant adverse impacts on human health and the environment.

Key Approaches and Procedures for Management including Enforcement and Monitoring Requirements

The key approaches for POPs management that currently exist include:

- Banning the production and importation of POPs pesticides according to the public health law
- Banning the importation of hazardous and toxic wastes
- Controlling the import and export of toxic and hazardous wastes

The use of POPs pesticides has been restricted since 1999 and the ban on importation has been in effect since 2000. Officially, there has been no record of importation of these pesticides.

Liberia is a signatory to the Basel Convention and there is no record of PCB exportation.

The government once initiated a program to manage PCBs. LEC, FPCO, EM and UL were selected for the initial identification of PCBs in Liberia. FPCO and EM did not respond and the assessment was only confined to the LEC facilities. There is no other active monitoring program for measuring PCBs in electrical equipment or in the environment and no other programs for the measurement of ambient levels of PCBs or other POPs chemicals in Liberia.

There are no specific measures for reducing the formation of dioxins and furans during the burning of garbage. An enforcement mechanism banning open burning was suggested at a solid waste management meeting.

Recommendations Relating to Legal Framework

The following are recommended in improving the legal response of Liberia to POPs issues:

1. Increased training for persons involved in enforcement of POPs protocols.
2. Amendment to the Liberian Commercial Code to make importation and distribution of POPs, offenses with civil and criminal sanctions.
3. Codification of remediation duties and end-of-life responsibilities for producers and distributors of POPs.

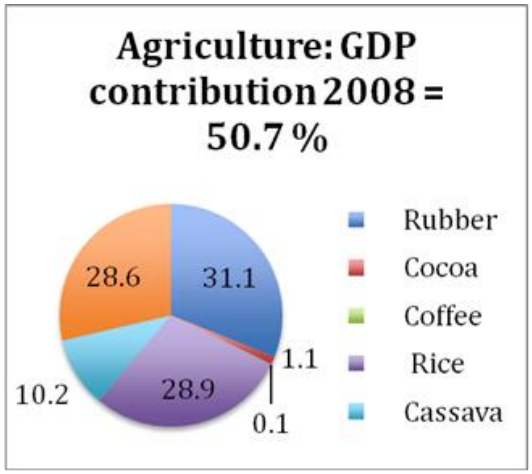
6. POPs Inventory

Agricultural sector - POPs Pesticides

The formal Liberian economy is based on natural resource extraction. The economy remains predominantly agrarian, producing rubber, coffee, cocoa, rice, cassava (tapioca), palm oil, sugarcane, bananas, plantains, sheep, goats, sweet potatoes, corn, citrus, pineapple, vegetables and timber (see figure 5). Agriculture is critical to the economic development of Liberia and is the source of livelihood for 70 percent of the population. Agriculture remains the largest economic sector in the country and contributed 50.7 % to the national GDP in 2008 (LISGIS, 2011).

Due to the insecurity caused by the conflict, many fields were left unplanted and food production plummeted. Production has not yet recovered to pre-war levels and the county must import rice to meet its needs. In the aftermath of the conflict, Liberia is now one of the most foods insecure countries in the world, with more than one third of its population undernourished.

Figure 3 Agriculture - Contribution to GDP in 2008 (LISGIS, 2011)



The majority of Liberia's country's population depends on agriculture with shifting cultivation, low input/low output and mixed crops as the principal farming system. It is thought by the editors of the draft UNITAR National Chemicals Profile (2010) that the use of chemical inputs such as pesticides and fertilizers is not widespread among traditional farms, mainly because of poverty and customary practices. Modern vegetable gardeners, using small plots of land, usually employ pesticides (UNITAR, 2010). Unfortunately, Liberia has never conducted an inventory of agro-chemical stocks, import, usage and export and thus the degree of potential environmental and health risks posed by these agrochemicals is unknown.

Some information on chemicals use by category exists for agricultural chemicals, but records differ between departments/databases and are not up to date. MoA imported in 2010 pesticides with a total value of 154,000 US$ (according to the MoA all pesticides are imported into the country as no manufacturing of agrochemicals is taking place in Liberia). It has to be noted that all of these pesticides are for distribution by the MoA's extension officers located in each of the 14 MoA District Offices and are intended for small-scale farmers. Commercial farmers and plantations import their agro-chemicals themselves through distributors. Detailed information might be available through BIVAC, agro-chemical distributors or the commercial plantations. Considering the porous border, the MoA also believes that (illegal) pesticides might also be entering the country without any controls.

The MoA does have a list of banned chemicals, but the MoA also indicated that it currently does not have any guidelines or rules governing the use, storage, and application of agrochemicals. The MoA also indicated that it does not have much control over the use and/or management of pesticides as these are most often distributed to farmers without the necessary training/information. Liberia has 14 countries, and each county has its own local MoA district office – which has agricultural officers, extension officers, planning, etc. The provision of services and the distribution of tools, fertilizers and pesticides has been decentralized. When farmers come to a MoA district office and ask for assistance, an assessment is carried out (type of crops, area coverage, etc.) based on which the district office calculates the type and amount of tools needed, the quantity of fertilizers and pesticides needed, etc. These requests are centrally procured and subsequently distributed to the 14 counties, which have their own warehouses/storage facilities and undertake their own dissemination

Persistent Organic Pollutants (POPs) pesticides (EPA, 2006)

POPs pesticides have never been produced in the country, and since 1999 the use of POPs pesticides has been restricted and the ban on importation has been in effect since 2000. The ban is also in effect for the use of DDT for vector control. There are no official records available on the past or current importation of POPs pesticides.

Nevertheless, DDT and Dieldrin are still in use in Liberia. Chlordane is reportedly being used but has not been confirmed. The POPs pesticides are offered for sale in local general markets (e.g. Duala Market and Paynesville Red Light Market) where pesticides are sold in small quantities in often-unlabeled containers.

Potential Environment and Health Implications from Chemicals used in Agriculture

Potential environmental impacts from the unsound management, use and disposal of chemicals in the agricultural sector could be (among else), water, soil and air pollution. The causes of pollution are relatively similar for each media:

Water- (ground and surface), Soil- and Air- Pollution resulting from:

- Inappropriate application and over-use of pesticides/fertilizers resulting in run-off due to over-application, contaminating fish-stocks and causing nitrification (among else).
- Runoff from farmlands to streams resulting from e.g. the coagulating of latex on trees (the main cause of acidity in rural streams and nitrification); production of palm oil on water banks (effluent containing phospholipids, run-off into the water killing fish, and promoting parasitic life forms).
- Lack of awareness on Good Agricultural Practices (GAP).
- Inappropriate storage and disposal of (obsolete) agrochemicals (including POPs).
- Lack of good waste management practices in combination with the unavailability of suitable temporary storage/disposal sites.
- Unsafe storage, disposal and re-use of old containers.

Human health effects from exposure to agrochemicals can occur through various ways, for example from drinking contaminated water, eating contaminated food, occupational exposure, or living in areas that are contaminated with hazardous or toxic agro-chemicals. The unsound management of agrochemicals can result in health expose and ill health as a result of (among else):

Chemical residues in foodstuffs for consumption, as a result of:

- Inappropriate application of agricultural chemicals.
- Insufficient monitoring of food quality.
- Use of illegal pesticides (e.g. POPs) from obsolete stocks or from illegal import.

- Inappropriate (re) packaging of agricultural chemicals resulting in chemicals that are often not labeled and don't contain information on handling, storage, disposal, etc.

Pesticide poisonings, as a result of:

- Inappropriate labeling – often as a result of (re) packaging of agricultural chemicals, resulting in chemicals that are often not labeled and don't contain information on handling, storage, disposal, etc.
- Inappropriate use and application.
- Suicides.

Human health effects from occupational exposure to agro-chemicals, as a result of:

- Lack of adequate labor protection regulations and their enforcement.
- Lack of training/awareness on safe use.
- Inappropriate personal protection and hygiene of pest control operators and agricultural workers.
- Growers making their own formulations.
- Use of illegal/hazardous substances.
- Inappropriate labeling.

Fishing

Liberia is situated within the East Central Atlantic region of the Gulf of Guinea, the continental shelf along the 579 km long Atlantic coastline averages 34 km in width, the fishing grounds cover 186 322.2 km² within the exclusive economic zone (EEZ). The fishing area extends from the shrimp rich shebro grounds bordering Sierra Leone in the west, to the Cavalla River Basin bordering Côte d'Ivoire. There are also 1,800 km of rivers endowed with a rich aquatic fauna (EPA/UNEP, 2007). FAO estimated Liberia's fisheries GDP at 12% of total agricultural GDP in 2005 (FAO, 2007). Liberia fisheries are made up of marine fisheries, involving industrial and artisanal activities; inland fisheries which are mainly artisanal; and aquaculture through subsistence fish farming. The fisheries are important for several reasons:

- They provide a means of employment and livelihood for about 11,250 people who are engaged on a full-time basis and perhaps hundreds of thousands more on a part-time basis.
- They provide a cheap source of animal protein for the population.
- They are a potential source of foreign exchange and revenue, as tuna, lobsters, shrimp, etc., abound in both fresh and marine waters.
- The sector provides about 65 percent of the animal protein needs of the country and contributes about 3.2 percent to the GDP (FAO, 2007).

Artisanal fishing (Coastal & Inland)

Approximately 60% of the total domestic catch is landed by artisanal fisher folk, using various types of canoes and fishing gear, including 200-800m long beach seines. About 13,000 fisher folks and 18,000 fish processors (mongers) and their families live in 139 communities in coastal counties. Together they operate about 3,500 canoes of which 8% are motorized and the largest numbers of canoes are operating in Montserrado and Grand Bassa County.

Inland fishery is underdeveloped and traditional in the methods of exploitation, and not monitored. As such, there is no information on its level of production (FAO, 2007). However, inland fisheries are a significant source of livelihood and protein for most households. Moreover, most of the fishing is undertaken by women using baskets and other local technologies. It is significant that these fisheries be managed properly in order to give rural women sustained access and control over a key livelihood resource (PEI, 2010).

Commercial Fisheries

Currently there are 14 fishing companies operating legally in Liberia; 6 companies are solely engaged in the importation of frozen fish from the high seas, and 8 companies are engaged in industrial fishing activities operating 30-40 licensed fishing vessels—including eight Chinese paired trawlers—with a combined Gross Registered Tonnage (GRT) of about 5,000 tons. Industrial fishing vessels land their catches at the fishing pier in the Free Port of Monrovia. Currently, fish landed locally by all licensed trawlers is estimated at 2,000-3,000 tons. However, BNF believes that these figures are grossly misreported, and has a strong suspicion that a number of licensed industrial fishing vessels are engaged in illegal transshipments in the high seas and are repacking catches in Liberian waters and declaring these catches as imports. BNF estimates that Liberia loses approximately US$ 10-12 million through illegal fishing each year. BNF further estimates that the annual catch within the EEZ of Liberia is much higher as poaching (pirate fishing) is rampant due to the lack of any monitoring, control and surveillance system. BNF conservatively estimates that there may be upwards of 250 "pirate" boats operating in Liberian waters, the majority of which are using illegal fishing techniques such as long lines and gear (nets with mesh sizes below the required size of 25mm for shrimp and 70mm for fish). Often these boats operate within the three-mile limit reserved for artisanal fisheries and compete for the same demersal species.

Potential Environment and Health Implications from Chemicals in the Fishery Sector

The most significant environmental and economic threat to the fishery sector is over-fishing (USAID, 2008). Nevertheless, there are significant environmental and health threats related to the use of chemicals in the fishery sector as well as the implications of the unsound management of chemicals in other economic sectors that negatively impact the fishery sector.

Surface water pollution impacting fish stocks and contaminating food sources, resulting from:

- Lack of awareness and training in Good Agricultural Practices, resulting in run-off contaminating and killing fish-stocks, causing nitrification and promoting parasitic life forms, due to e.g. the inappropriate application and over-use of pesticides/fertilizers; the coagulating of latex on the trees (the main cause of acidity in rural streams and nitrification); production of palm oil on water banks (effluent containing phosphor-lipids).
- Lack of municipal, hospital, hazardous and toxic waste management practices in combination with the un-availability of suitable disposal sites, resulting in dumping of waste in water streams, mangrove forests and waste leachate ending up in water bodies. The biggest threat to mangroves is urban expansion and accompanying landfills, particularly in Monrovia. The Mangroves are vital coastal system, and among else they provide spawning grounds for many fish species, crabs, shrimps, mollusks and other forms of sea life (UNITAR, 2010).
- Inappropriate storage and disposal of chemicals and their containers resulting in leakage and seepage into water bodies (agro/forestry chemicals, petrochemicals, POPs, etc.)
- Oil spills and chemical discharges at sea resulting from and oil and gas exploration.

- Impact of chemicals used in the fishing sector (artisanal and commercial) leading to environmental and health impacts:
- Use of organic and chemicals pesticides and dynamite for in-land fishing
- Unsound management of cooling gas (HCFCs) and cooling equipment at cold storage facilities (on commercial vessels and on-shore) resulting in leakage of coolant gases to the atmosphere and contributing to climate change and ozone depletion.
- Dumping of (chemicals) wastes including oil spills from commercial fishing vessels pollution the ocean.

Step – by –Step Methodology for Inventory preparation.

- o Inventory document of POPs pesticides including stockpiles and wastes.
- o Stakeholders to be informed about the issues of pops pesticides and the presence of these chemicals in the country.

Phases for inventory preparation:

Phase I – Inventory Preparatory Activities.

1. Introductory workshop on the planning of the future management of pops pesticides in the country. The objective would be to include stakeholders in the area of pesticides and share general information on pops pesticides.

2. Special task force group for inventory preparation. A special task group for planning, organizing and partly undertaking the work involved should be appointed.

3. Development of a work plan showing major tasks to be undertaken and a timescale for completing the work.

Phase II- Inventory preparatory activities.

1. Preparation of a national inventory of POPs pesticides the steps are:

Establish an overview of the size and nature of the POPs pesticides issue based on existing information.

Examples of POPs pesticides are aldrin, chlordane, DDT, dieldrin, endrin, mirex, heptachlor and toxaphene that have been subject to the initial NIP on POPs (2004). There is also a growing concern over the effects of the newly included pesticides such as chlordecone, endosulfan and lindane with the buy-products alpha and beta hexachlorcyclohexane. All are sometimes compounds used mainly as insecticides.

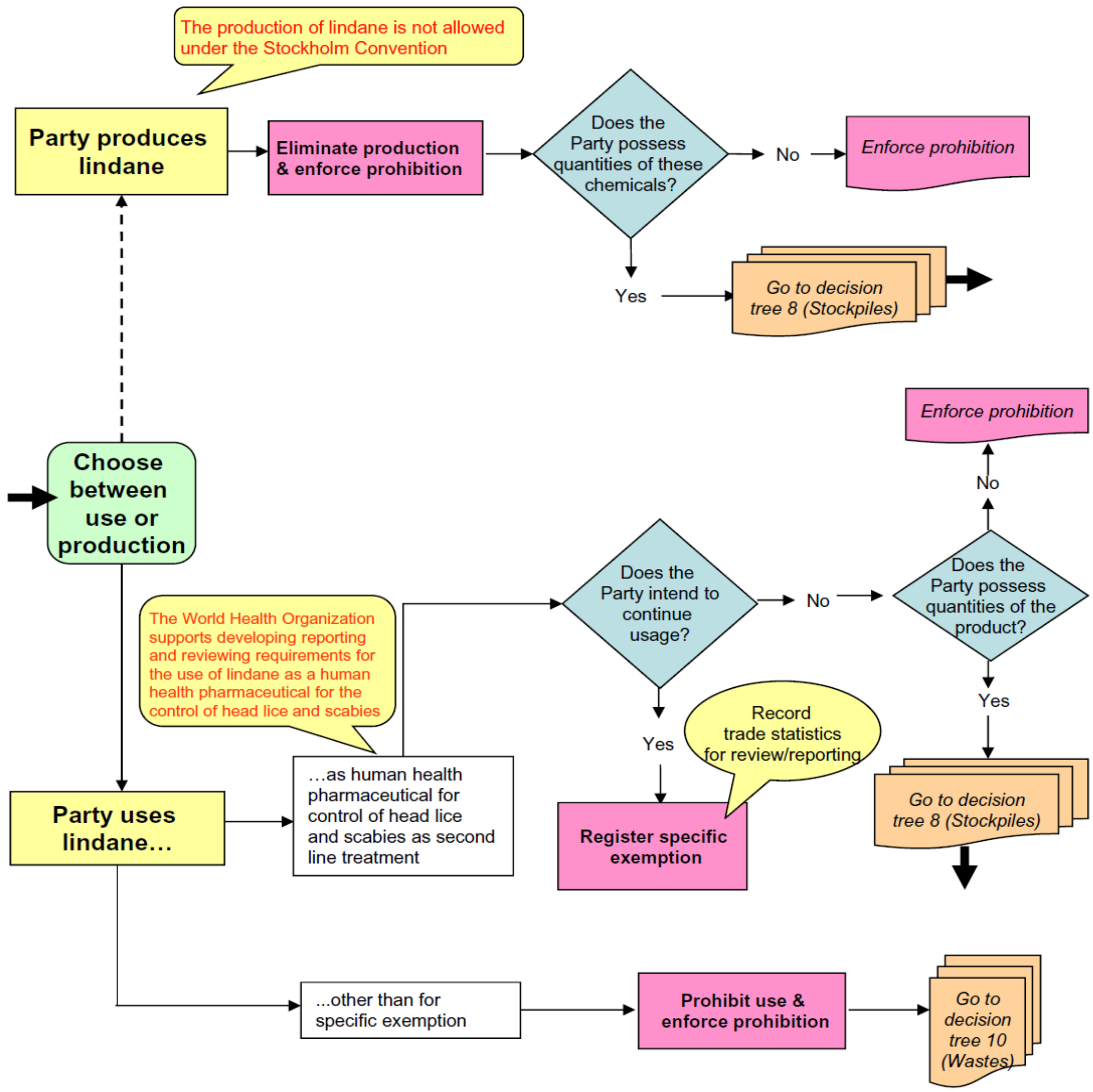
Table 2: Old and New POPs

POPs Groups	Old 12 POPs	New 11 POPs
POPs Pesticides	Aldrin, DDT, Endrin, Dieldrin, Chlordane, Mirex, Toxafene, Heptachlor, Hexachlorobenzene	Lindane, Chlordecone, Pentachlorobenzene, α-HCH, β HCH δ HCH,Endosulfane, endosulfan
Industrial POPs	PCBs	PFOS, PBDE (hexabromobiphenyl,

POPs Groups	Old 12 POPs	New 11 POPs
		hexabromodiphenyl ether and heptabromodiphenyl ether, Tetrabromodiphenyl ether и Pentabromodiphenyl ether)
Unintentional POPs	PCDDs, PCDFs, PCBs, HCBs	α-HCH, β HCH, δ HCH, PeCB Pentachlorobenzene

The use of Lindane is questionable in Liberia as no investigation or assessment has been done on the use and importation.

Figure 4.Intentionally produced POPs with specific exemption: Lindane



POPs characteristics of Endosulfan

According to the risk profile on endosulfan, adopted by the POPs Review Committee of the Stockholm Convention (POPRC), endosulfan is persistent in the atmosphere, sediments, and water. Endosulfan bioaccumulates and has the potential for long-range transport. It has been detected in air, sediments, water, and in living organisms in remote areas, such as the Arctic, that are distant from areas of intensive use.

Endosulfan is toxic to humans and has been shown to have adverse effects on a wide range of aquatic and terrestrial organisms. Exposure to endosulfan has been linked to congenital physical disorders, mental retardations, and deaths in farm workers and villagers in developing countries in Africa, Asia, and Latin America. Endosulfan sulfate, a transformation product of endosulfan, shows toxicity similar to that of endosulfan.

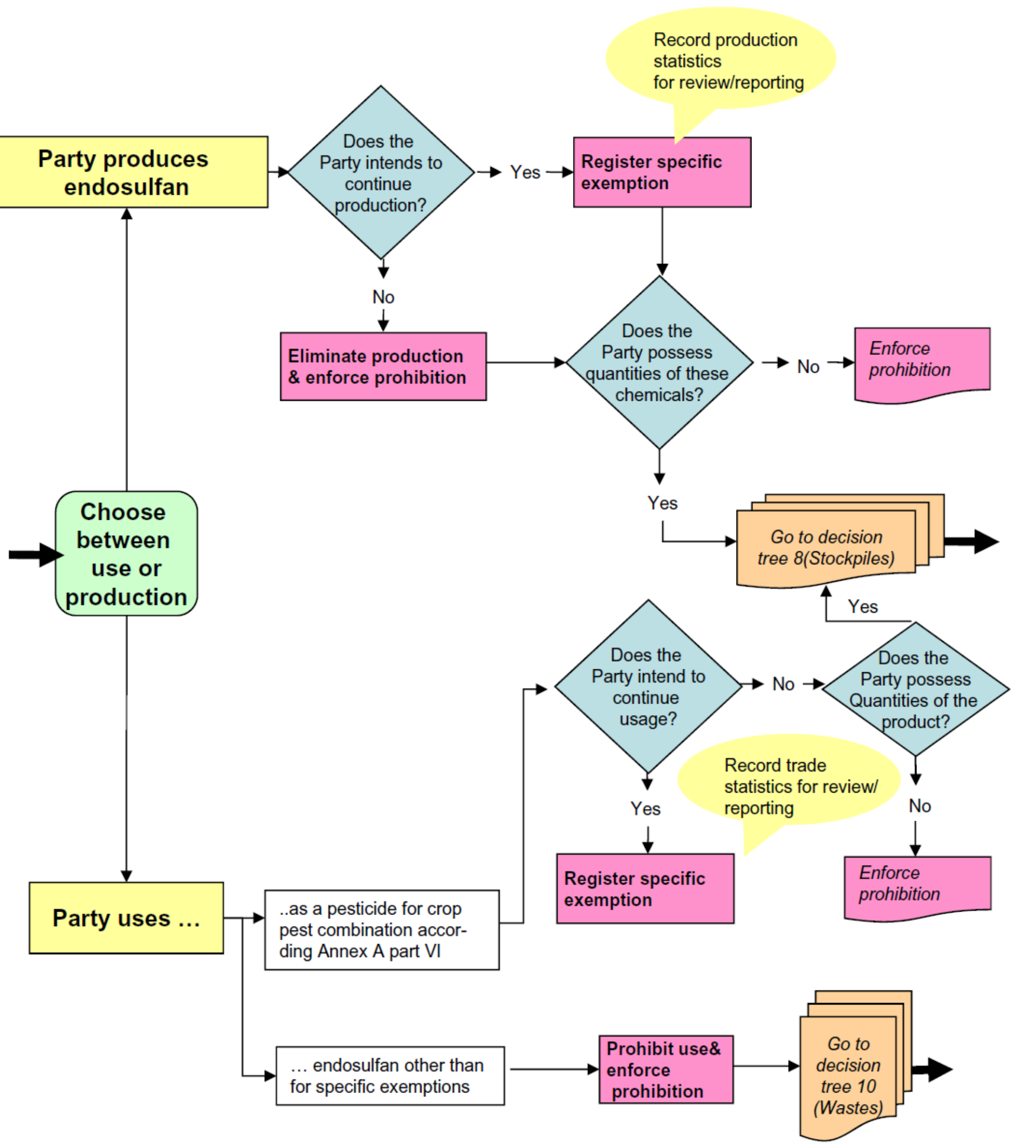
Use and production

According to the risk management evaluation on endosulfan, adopted by POPRC, endosulfan is an insecticide that has been used since the 1950s to control crop pests, tsetse flies and ectoparasites of cattle, and as a wood preservative. As a broad-spectrum insecticide, endosulfan is currently used to control a wide range of pests on a variety of crops including coffee, cotton, rice, sorghum, and soy.

Obligations under the Convention

Endosulfan is listed under Annex A. Parties must take measures to eliminate the production and use of endosulfan from 27 October 2012 onwards. Liberia has not asked for exemption.

Figure 5. Intentionally produced POPs with specific exemption: Endosulfan



7. Inventory of industrial POPs, categorization and background information on old and new POPs

Currently, there are seven chemicals that have been identified by Stockholm Convention as old and new industrial POPs:

1. Hexachlorobenzene (HCB) Old POPs
2. Polychlorinated biphenyls (PCBs) Old POPs
3. Commercial pentabromo diphenyl ether (c-PentaBDE) (Tetrabromodiphenyl ether and pentabromodiphenyl ether)
4. Commercial Octabromodiphenyl ether (c-OctBDE) (Hexabromodiphenylether and heptabromodiphenyl ether)
5. Hexabromobipehyl (HBB)
6. Perfluorooctane sulfonic acid (PFOS), its salts perfluorooctane sulfonyl fluoride (PFOS-F)

HEXACHLOROBENZENE(HCB)

Hexachlorobenzene is a by-product of the manufacture of industrial chemicals including carbon tetrachloride, perchlorethylene, trichloroethylene and pentachlorbenzene. It is also a by-product in the manufacturing of industrial chemicals. Its major use in 1945, as fungicide, was seed treatment, especially for control of burnt of wheat. It was used to make fireworks, ammunition, wood preservatives, dyes and synthetic rubber.

Processes that form HCB as byproducts are: manufacture of other chemicals, chemical interactions in waste streams of chloralkali and wood-preserving plants and burning of municipal waste.

Hexachlorobenzene is one the first twelve chemicals named as "dirty dozen" by the Stockholm Convention. It was listed under Annex A and Annex C with specific exemptions: production opportunity is given to only registered parties while its use is only allowed as chemical intermediate and a solvent for pesticides.

POLYCHLORINATED BIPHENYLS (PCBs)

Polychlorinated biphenyls are used in a variety of industrial applications, such as dielectrics in transformers and large capacitors, as heat exchange fluids, as paint additives, in carbonless copy paper and in plastics. Their degradation in the environment depends largely on the degree of chlorination of the biphenyl, with persistence increasing as the degree of chlorination increases.

Half-lives for PCBs undergoing photodegradation range from approximately 10 days to 1.5 years. Scientific studies have shown that polyhalogenated aromatic hydrocarbons such as PCBs are highly persistent and are linked to reproductive and immunotoxic effects in wildlife. The main source of PCB exposure to the general population is through food, especially fish. Children born seven to twelve years after maternal exposure experienced mildly delayed development, but no differences in behavior. Effects observed in these children are likely a result of the persistence of PCBs in the human body, resulting in prenatal exposure long after the exposure took place. There is sufficient evidence of carcinogenicity in experimental animals. Therefore, PCBs are classified as probable humans' carcinogens.

Polychlorinated biphenyls are also part of the first twelve chemicals named "dirty dozen" by the Stockholm Convention. They are listed under Annex A with specific exemptions and under Annex

C. This means production is completely banned but usage is allowed in accordance with part II of Annex A.

PBDEs (c-PentaBDE and c-OctaBDE)

Commercial pentabromodiphenyl ether (C-PentaBDE) and commercial octabromodiphenyl ether are mixture of brominated flame retardants (BFRs) in the form of additives in consumer articles such as plastics in electronics, upholstery in transport and furniture or textiles. The acronym PBDEs is used for the generic term polybromodiphenyl ether, covering all congeners of the family of brominated diphenyl ethers. PBDEs were produced at three different degrees of bromination, in particular commercial Pentabromodiphenyl ether (c-PentaBDE), and commercial Octabromodiphenyl ether (c-OctaBDE).

Due to the complication and magnitude of usage of the POP-PBDEs and other brominated flame retardants such as HBB, eliminating them represents a challenge for many Parties to the Stockholm Convention. These chemicals have been widely used in many industrial sectors for the manufacture of a variety of products and articles, including consumer articles. For example, POP-PBDEs have been used in the electronics industry for the manufacture of plastic casings.

The following industries were noted for the use of PBDEs, such as:

- Construction industry,
- Recycling industry,
- Textiles and carpet industry,
- Furniture industry,
- Transport industry,
- Electrical and electronic industries and
- Organobromine industry.

Even though these industries, except construction industry, are not operating in Liberia, it is obvious that products containing PBDEs are imported and used in Liberia. Some of these products have entered in the waste circle. Key products that contain PBDEs are plastics from imported electronics, plastics in electronic materials, polyurethane in cars that were manufactured before 2004 and polyurethane imported with goods such as mattresses, furniture etc.

Production of PBDEs was very high in 1990 - 2005. Though production have ceased in Europe in 1997 and in USA in 2004, products such as plastic materials in electronic equipment and furniture materials for vehicle that were manufactured during that period are still in circulation in the markets or as waste materials in the environment. Some of these expected to become waste serving as major POP-PBDEs contaminants. The major sources of contamination with PBDEs are presented on in the figure 6 shown below.

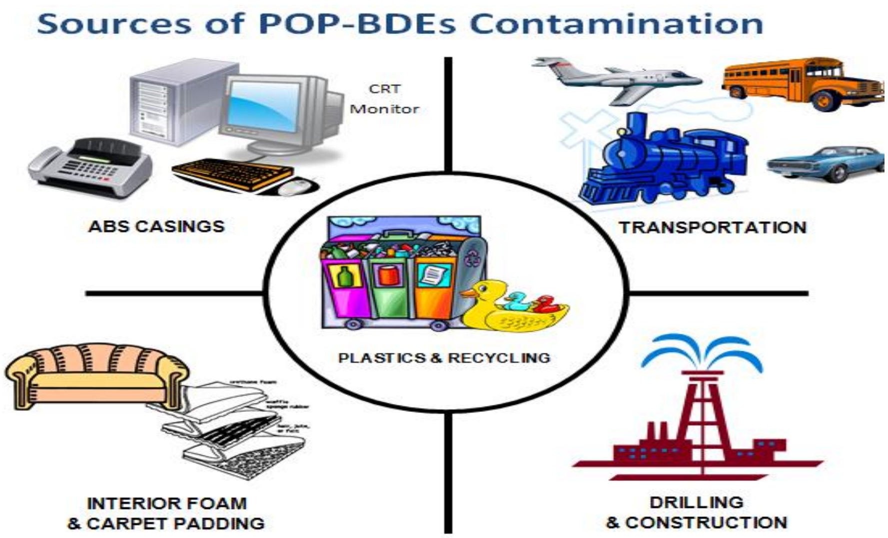


Figure 6: Sources of POP-BDEs contamination[3]

The producers of pentaBDE have provided information to the effect that pentaBDE is used today solely in different polyurethane (PUR) applications. According to DETR (2000), this PUR is in turn used mainly as PUR foam for furniture and upholstery in automotive industry and domestic furnishing. Other possible minor uses are in rigid polyurethane elastomers (e.g., in instrument casings), in epoxy resins and phenol resins (electric and electronic appliances).

The current use (as of year 1999/2000) of PentaBDE in flexible PUR covers ca. 95 % of the total consumption of PentaBDE in Europe (DETR 2000). PentaBDE was used in the past in minor amounts also in textiles, in mining industry rubber belts and in oil drilling fluids.

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. The average content of c-PentaBDE in PUR foam is around 3-5% for upholstery, cushions, mattresses and carpet padding. The main challenge for their elimination is the identification of existing stockpiles and articles containing PBDEs and their disposal at end of life. The schematic diagram of the life-cycle of products containing c-PentaBDE (during their production, in use and waste management) is presented on Figure 7 as shown below:

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[3] Source: Guidance for the inventory of polybrominated diphenyl ethers (PBDEs) listed under the Stockholm Convention on Persistent Organic Pollutants July 2012 www.unido.org/fileadmin/user_media/Services/Environmental_Management/Stockholm_Convention/Guidance_Docs/UNEP-POPS-GUID-NIP-2012-PBDEs-Inventory.En.pdf

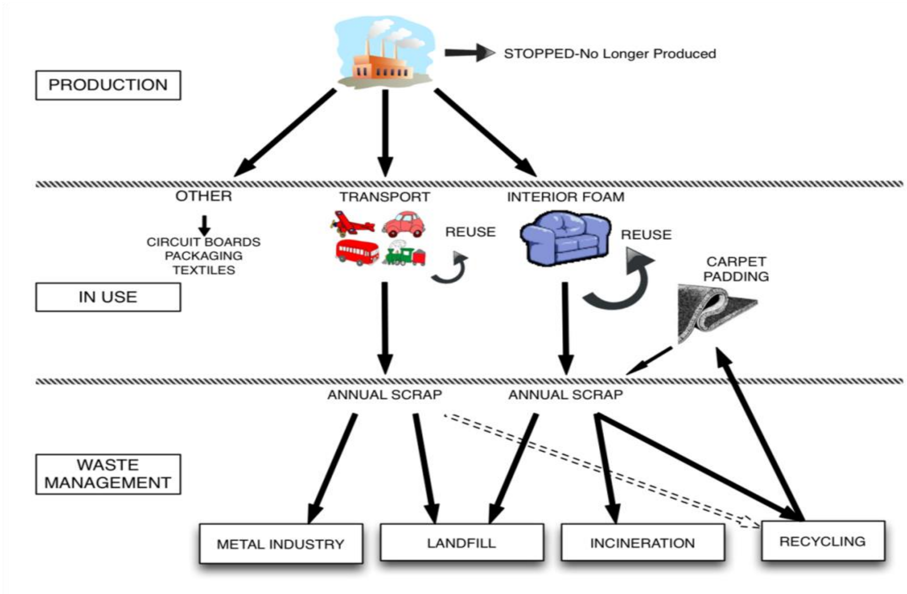


Figure 7 : Schematic diagram of the life cycle of c-PentaBDE and potential for emissions[4]

The table below summarizes the use of c-PentaBDE in polymers/resins, and application in commercial commodities:

Table 3 Use of c-PentaBDE in polymers/resins, and application in commercial commodities

Materials/polymers/resins	Application	Commercial commodities containing c-PentaBDEs
Polyvinylchloride (PVC)	Cable sheets	Wires, cables, floor mats, industrial sheets.
Unsaturated (Thermoset) polyesters (UPE)	Circuit boards, coatings	Electrical equipment, coatings for chemical processing plants moldings, military and marine applications: construction panels.
Hydraulic oils	Drilling oils, hydraulic fluids	Off shore, coal mining
Rubber	Transportation	Conveyor belts, foamed pipes for insulation.
Paints/lacquers	Coatings	Marine and industry lacquers for protection of containers

[4] Source: Guidance for the inventory of polybrominated diphenyl ethers (PBDEs) listed under the Stockholm Convention on Persistent Organic Pollutants July 2012 www.unido.org/fileadmin/user_media/Services/Environmental_Management/Stockholm_Convention/Guidance_Docs/UNEP-POPS-GUID-NIP-2012-PBDEs-Inventory.En.pdf

Epoxy resins	Circuit boards, protective coatings	Computers, ship interiors, electronic parts.
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.

Another component of PBDEs is the commercial octabromodiphenyl ether, c-OctaBDEs. Historically, c-OctBDEs were used in the production of acrylonitrilebutadiene-styrene (ABS) polymers. The ABS in turn was mainly used for housings/casings of Electrical and Electronic Equipment (EEE), particularly in Cathode Ray Tube (CRT) housings and office equipment such as copying machines and business printers, typically office equipment and business machines. Other minor uses were High Impact Polystyrene (HIPS), polybutylene terephthalate (PBT), Polyamide Polymers also mainly used in electronics and to some extent in the transport sector. A schematic diagram depicting life-cycle of products containing c-OctaBDEs, during their production, in use and waste management, is shown in figure 6 as seen below;

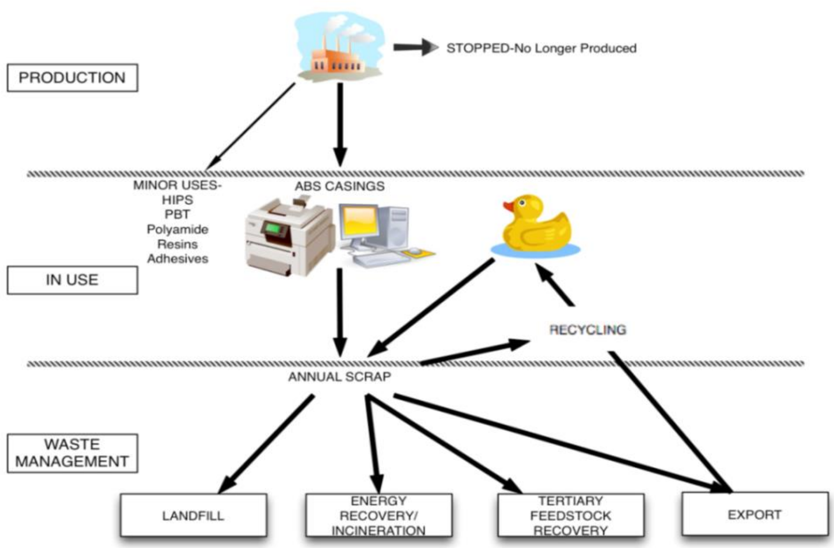


Figure 8. Schematic diagram of the life cycle of c-OctaBDE and potential for emissions[5]

[5] Source: Guidance for the inventory of polybrominated diphenyl ethers (PBDEs) listed under the Stockholm Convention on Persistent Organic Pollutants July 2012 www.unido.org/fileadmin/user_media/Services/Environmental_Management/Stockholm_Convention/Guidance_Docs/UNEP-POPS-GUID-NIP-2012-PBDEs Inventory.En.pdf

The major applications and product containing c-OctaBDE are presented in the table as shown below.

Table 4 Major applications and product containing c-OctaBDE

Polymers/materials	**Application**	**Product**
Acrylonitrile-Butadiene-Styrene (ABS)	Polymer casings/parts in Electric and Electronic appliances	Computer- and TV casings (CRTs); office equipment; (other electronic equipment)
High Impact Polystyrene (HIPS)	Polymer casings/parts in Electric and Electronic appliances	Computer- and TV casings (CRTs); office equipment;
	Cold-resistant layer	Refrigerator
Polybutylen-Terephtalate (PBT)	Polymer casings	Electronic appliances
	Electronic appliances	Electronic appliances
	Household	Iron
Polyamide polymers	Textiles	Furniture
	Construction	Pipes and plastic foil

PERFLUOROOCTANE SULFONIC ACID (PFOS), ITS SALTS AND PERFLUOROOCTANE SULFONYL FLUORIDE (PFOS-F)

Perfluorooctane sulfonic acid, PFOS, is a fully fluorinated octane sulfonic acid usually in the ionic form with all the hydrogen atoms substituted with fluorine atoms. PFOS is commonly used as a salt in some applications or incorporated into larger polymers. PFOS, its salts and PFOSF were purposely listed in the Stockholm Convention to restrict the use and production of PFOS and its related substances. PFOS is produced synthetically from PFOSF, and PFOS can be derived from its salts when dissolved PFOS related substances 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 are historically been used in a wide variety of applications, typically including firefighting foams and surface resistance/repellence to oil, water, grease or soil.

The following table presents the use of PFOS and related chemicals in different industrial sectors worldwide.

Table 5. Use of PFOS and related chemicals in different industrial sectors worldwide

Main category	**Application**

Surface Treatment	Textile mills, leather tanners, finishers, fiber production, carpet manufacturers Apparel and leather, upholstery, carpet, automobile interiors.
Paper production	Food contact applications (plates, food containers, bags, wraps), nonfood contact applications (folding cartons, containers, carbonless forms, masking paper)
Performance chemicals	Firefighting foams, Mining, acid mist suppressants for metal plating, electronic etching baths, photolithography, electronic chambers, hydraulic fluid additives, alkaline cleaners, shampoo, coating additives, carpet spot cleaner, insecticide

The uses of PFOS and its related substances listed in the Stockholm Convention as specific exemptions have a time limit of five years as of the time they were listed. Currently, the uses of PFOS listed in the Stockholm Convention are restricted. Such restriction will continue until suitable alternative substances and method are available.

OBJECTIVES OF THE OLD AND NEW INDUSTRIAL POPs INVENTORY

The overall objective of the old and new POPs inventory is to review Liberia National Implementation Plan, NIP, for the Stockholm Convention on Persistent Organic Pollutants, POPs. The Liberia NIP was compiled and published in 2006 and considering the time couple with the addition of new chemicals to be added the list of POPs, there is a need for the review of the NIP. Therefore, the main objectives of old and new industrial POPs inventory are:

- ✓ to identify contaminated areas (hot spots)
- ✓ to conduct gap analysis for the legal and institutional framework in relation to the control of production, use, import, export of new industrial chemicals and products potentially containing these products
- ✓ Prioritization of PFOS applications (due to the variety of applications) in relation to the application in the Liberia and the expected quantities
- ✓ to identify as much as possible sources of old and new industrial POPs
- ✓ to determine the stocked quantities of industrial chemicals by using the approach - "life cycle" of products
- ✓ to raise public awareness of the importance and application of old and new industrial chemicals
- ✓ to identify the possible presence, current use and management of industrial chemicals and products containing POPs in Liberia.

METHODOLOGY AND SCOPE OF THE OLD AND NEW POPs CHEMICAL INVENTORY

The task of reviewing and updating the Liberia National Implementation Plan, NIP, has been executed using the proposed steps and techniques set forth within the "Guidance for the inventory of polybrominated diphenyl ethers (PBDEs) listed under Stockholm Convention on Persistent Organic Pollutants" and "Guidance for the inventory of Perfluorooctane Sulfonic Acid and its derivatives listed under the Stockholm Convention on Persistent Organic Pollutants.

To kick off the work, several meetings, including workshops involving the relevant stakeholders, were held within the period August 2013 to April 2014 in order to set up working groups for the review and update of the NIP taking into consideration the new chemicals added to the list of POPs by the POPs review Committee of the Stockholm Convention. Accordingly, a three-man team was established as a group to review and update the old and new industrial POPs. Seven different chemicals were identified in this category. These chemicals are hexachlorobenzene (HCB), polychlorinated biphenyl (PCBs) as old industrial POPs and commercial pentabromodiphenyl ether (c-PBDE), pentachlorobenzene (PeCB), commercial octabromodiphenyl ether (c-OBDE), hexabromobiphenyl (HBB) and perfluorooctane sulfonic acid and it salt as new industrial POPs.

The group subsequently met to discuss which of these chemicals are still in use in Liberia, what is the import-export regime, what could be the main sources of information and data for quantities of chemicals, products containing POPs chemicals or processes that use these chemicals in order to calculate the quantities of old and old and new industrial chemicals. What types of consumer products are on the market containing the old and new industrial POPs (PBDEs and PFOS) on stock and is there data available about the waste management of this type of products containing old and new industrial POPs? The group also performed prioritization among the processes, industrial sectors and services in Liberia where the old and new industrial chemicals could be found in order to approach those sectors first. The members of the group for old and new industrial chemicals POPs are presented in Annex 1

The inventory was carried out using the following steps and techniques:

- ✓ Preparation of questionnaire to access information from stakeholder institutions handling chemicals
- ✓ Conducting workshops with relevant institutions with aim of information and data gathering regarding old and new industrial POPs.
- ✓ Review chemical importation information by assessing records from institutions such as Bureau of Inspection Valuation Assessment and Control (BIVAC), Ministry of Commerce, and Firestone Liberia.
- ✓ Visit to the Department Vehicles registration Ministry of Transport, to assess manufacturing date of vehicles and the country of origin.
- ✓ Visit to General Service Agency (GSA), an institution responsible for all government vehicles and has the statistics of all government expired electronic equipment.
- ✓ A stopover the Liberia National Fire Service to assess the type of firefighting materials used by this institution.
- ✓ A stopover to the Liberia Electricity Corporation to inquire the existing of the transformers containing PCBs and ascertain whether the new transformers in use do not contain any form of PCBs.
- ✓ Stopover to nearly all cars importers parking lots to assess vehicles manufacturing date and countries of origin.
- ✓ Visit to Whein Town (solid waste land fill site) and several solid waste transfer stations.
- ✓ Stopover to several mattress factories to ascertain whether their polymers materials do not contain PFOS and its salts.
- ✓ Visit to paint factory to assess additives use in paint production.

HEXACHLOROBENZENE (HCB) INVENTORY

Hexachlorobenzene, also known as HCB, is a white crystal-looking solid. It is found naturally in the environment but is produced as by-product during the production of other chemicals. Hexachlorobenzene is found in annexes A and C of the Stockholm Convention. It falls in the category of industrial POP because it is generated as a by-product during production of other chemicals and it is used in the production of fireworks, ammunition, and synthetic rubber. Hexachlorobenzene also falls in the categories of POP pesticide and unintentional POP because, historically, it was used as a fungicide and it emitted open air burning of waste.

There are some indications that any process that produce dioxins or dibenzofurans (e.g., pulp and paper mills using chlorine for bleaching) will also yield other chlorinated organic compounds such as hexachlorobenzene. In addition, hexachlorobenzene may be produced as a byproduct in waste streams of chloralkali plants and wood preserving plants, and in fly ash and flue gas effluents from municipal incineration

HCB INVENTORY RESULTS

Liberia is not a chemicals producing country, as such, hexachlorobenzene is not produced in Liberia. The use of HCB as pesticide has been banned in Liberia except it is smuggled into the country under difference trade mane. The unintentional POP characteristics of hexachlorobenzene are what needs to be investigated due to the practice of open air burning of wastes assorted waste in Liberia. However, it expected that the team dealing with unintentional POPs inventory will do a detail inventory on HCB.

Inventory on polychlorinated biphenyl (PCBs) (an old industrial POP)

Polychlorinated biphenyls (PCBs) are group of organic compounds comprising two benzene rings joined by a single carbon-carbon bound with some of the hydrogen atoms on the benzene rings being replaced by chlorine atoms. They are solids or oily liquids.

Historically, PCBs have never been produced in Liberia. However, it is evident that PCBs containing materials such as electrical equipment (transformers and capacitors) are found in Liberia. According to Liberia 2006 published NIP, (chapter 5, page 33 under subtitle "assessment with respect to Annex A part II Chemicals (PCBs), about 3,000 to 4,000 transformers were installed national wide prior to the inception of the civil war. Unlike the capacitors which were found to contain non-PCB dielectric fluid, the transformers surveyed were divided into three categories as shown below.

Table 6. Transformers surveyed were divided into three categories

Nature of transformer	Assumed concentration of PCBs.
Transformers without nameplate or supplier	500ppm
Transformers with nameplate and supplier but type of dielectric fluid not indicated.	500ppm
All transformers containing mineral oil with unknown concentration of PCBs	50 - 499ppm

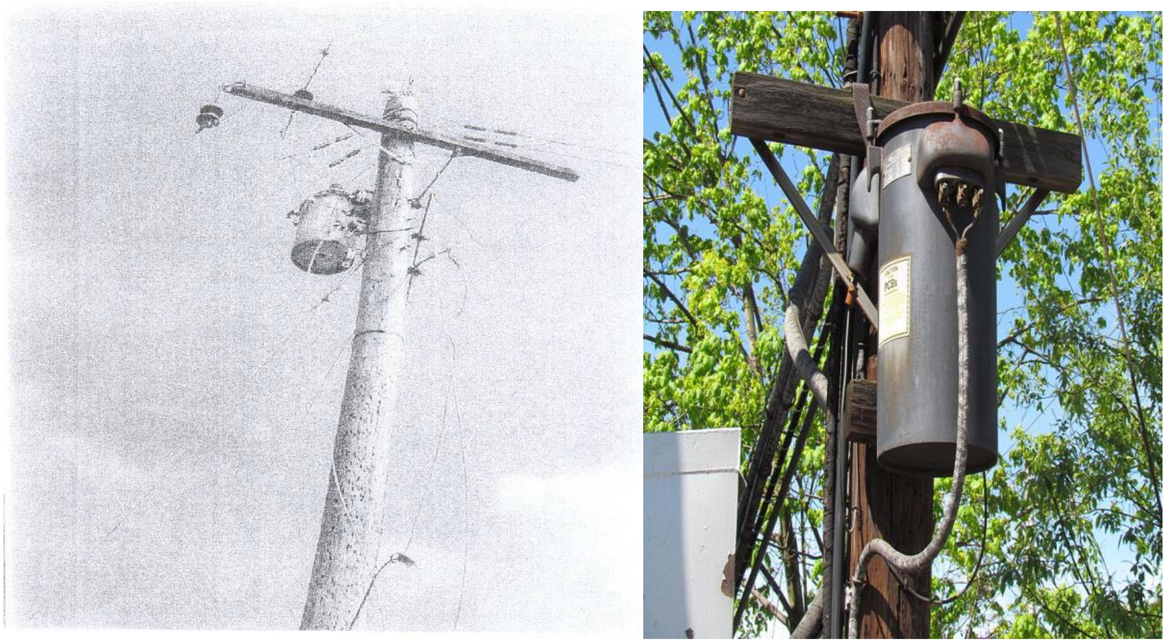


Figure 9. Type of transformers used before 1989. Pole mounted transformer made in Germany

Detailed PCBs inventory (an old industrial POP)

PCB being an old industrial POP, it was covered in the 2006 NIP. Hence, the team work started with checking the status PCBs as revealed in the NIP. Accordingly, of the estimated 3,500 transformers that were installed nationwide before 1989, about 1120 transformers were functioning and covered during the inventory in 2005 for the NIP. The balanced transformers, about 68% (2,380 transformers) were destroyed during the civil war which lasted from 1989 to 2003.

Base on this background information, the team initially attempted to find the number of old transformers in the environment in the form of scrap materials. Several sites suspected of having abandoned and obsolete transformers were visited by the team. No remnant of the old transformers was found. The only power generating company currently operating in the country is the Liberia Electricity Corporation (LEC). The team visited the head office of LEC including all the sub-station in Monrovia and its environs. Findings from LEC coverage area are summarized below:

Table 7 Inventory of transformers under the Liberia Electricity Corporation

Year	No. of Transformer	Type	Manufacturing Company	Country of origin
2010 - 2012	1,255	Pole mounted	Nucon Switch Grears	India
2012 - 2013	1,318	Pole mounted	Nucon Switch Grears	India

2010 - 2010	Quantity not specified	Transformer oil	ENOC ARC	China

The nameplate of all the transformers that were assessed on the Bushrod Island Compound of LEC only indicated the name of the transformer, the manufacturing company and the country from which the transformers are made. The transformer oil is manufactured by the ENOC ARC Company and it imported from the People Republic of China. Effort by the team to know the composition and quantity imported into the country proved futile.

8. INVENTORY ON NEW INDUSTRIAL POPs

Inventory on PBDEs and HBB

Polybrominated diphenyl ethers (PBDEs) are group of organic compounds comprising two phenyls molecules that are separated by a carbon - oxygen - carbon bridge; the two carbon atoms are part of each benzene ring. These compounds are derivatives of water in which the two hydrogen atoms are replaced by two polybrominated phenyls. Hexabromobenzene (HBB), on the other hand, comprises a single benzene ring in which all the six hydrogen atoms are replaced be six bromine atoms. Technically, HBB may be seen as moiety of PBDEs. Several of PBDEs do exist in different forms known as congeners. However, this inventory is basically focused on commercial pentabromo diphenyl ether (c-PentaBDE) which is a mixture of tetrabromodiphenyl ether and pentabromodiphenyl ether, commercial octabromodiphenyl ether (c-OctaBDE) which is also a mixture of heptabromodiphenyl ether and octabromoodiphenyl ether and hexabromobenzene.

While it is understandable that these compounds have never been produced in Liberia, there is clear indication that these chemicals are either imported or are found as additives in consumer products such as plastics in electronics, upholstery in transport and furniture or textiles that in circulation in the country. Polybrominated diphenyl ethers and hexabrombenzene are use as additives in flame retardants. Due to the wide range of application of these chemicals, they are used in the following sectors:

- ✓ Organobromine industry
- ✓ Electrical and electronic industries
- ✓ Transport industry
- ✓ Furniture industry
- ✓ Construction industry
- ✓ Recycling industries.

According to "Guidance for the inventory of PBDEs" and other literatures produced by the Stockholm Convention, production of PBDEs ended in 2004 in the USA and ended in other PBDEs producing countries in 2005. Based on this information, the team focus was concentrated on taking inventory of PBDEs containing materials that were manufactured before 2005. Countries in which these materials are made were also researched.

Table 8 Stakeholder institutions consulted during the inventory.

Stakeholder institution	Purpose for consulting each Ministry/Agency

EPA	As a regulatory authority in Liberia, the team thought EPA could have national data of chemical related materials
Firestone Liberia	In search of information on new industrial POPs, the team thought Firestone, as largest rubber farm in Liberia, could be using some of the new industrial POPs in and form.
Ministry of Transport	The team consulted the Ministry of Transport seeking statistical data of the number of vehicles imported into the country for the past three years
General Service Agency (GSA)	GSA is responsible secure and dispose of all government expired vehicles including electronic equipment. The thought GSA could have data on these materials disposed of on behalf of government
Liberia Electricity Corporation (LEC)	The team gathered information (very important for PCBs inventory)
Liberia National Fire Service	The team sought information regarding the types of fire fight materials that are being used by the Liberia National Fire Service.
Mattresses producing factories	Team gathered information concerning raw materials used in the making polymers.
Monrovia City Corporation	Information seeking regarding how solid wastes are processed and disposed of.

Results of PBDEs and HBB inventory

The main challenge faced by the team was assessing suitable data sources to obtain the needed information. Data collected from the Transport Ministry(MOT) and the General Service Agency (GSA) are used to determine and assess the quantity of c-PentaBDE judging from the number of vehicles, manufacture before 2004, they are still in use in the Republic of Liberia. The table shown below presents the quantity and types of vehicles imported into the country in 2011, 2012 and 2013.

Table 9 Quantity and types of vehicles imported into the country in 2011, 2012 and 2013

	2011	2012	2013	Total vehicles imported from 2011 to 2013
Cars with manufacturing date(1990 - 2005	10,208	11,945	12,459	
Buses with manufacturing date (1990 - 2005	491	575	600	

Trucks with manufacturing date (1990 -2005	523	612	638	↓
Cars, buses and trucks with manufacturing date(200 5- 2014)	1,493	1,747	1,822	
Cars, buses and trucks with no information of manufacturing date	1,685	1,971	2,056	
Total vehicles imported per year	14,400	16,850	17,575	48,825

The calculation of the distribution of c-PentaBDE is based on the number of vehicles older than 2005.

Table 10 Vehicles in the Republic of Liberia imported, registered and still in use.

Number of vehicle containing c-PentaBDE still in use in the Republic of Liberia; determined in 2014	
Cars **Busses** **Trucks**	**34, 612** **1,666** **1,773**
Total	**38,951**

Using UNIDO guidance and recommendation in calculating the number of c-PentaBDE embedded in vehicles, the following values were determined as shown in the table.

Table 11 Distribution of quantity of c-pentaBDE in the transport sector in Liberia for 2014

Distribution of quantity of c-pentaBDE in the transport sector in the Republic of Liberia for 2014.	
Cars	276.9kg
Busses	83.3kg
Trucks	14.2kg
Total	**373.4kg**

Distribution of quantity of c-PentaBDE in the transport sector in the Republic of Liberia for 2014.Taking these values into consideration, the distribution of c-PentaBDE in transport sector in Liberia is expected to be 74% in cars, 22.2% in busses and 3.8% in trucks. The following figure 10, shows the initial distribution of c-PentaBDE in the transport sector in Liberia.

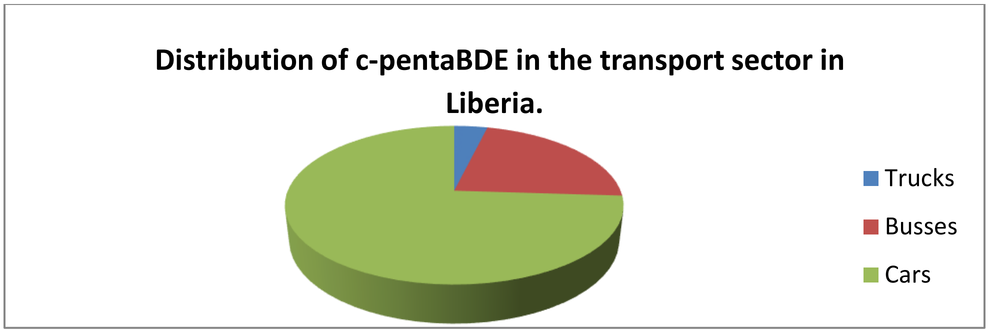


Figure 10 depicting distribution of the quantity of c-pentaBDE in the transport sector in Liberia

Inventory of POP PBDEs (c-OctaBDE) in electrical and electronic wastes could not be carried due to difficulties in obtaining data on electrical and electronic materials including E- waste. The team is still in search of these data and if succeed, the distribution c-OctaBDE, the principal constituent in electrical materials, will be determined in the final draft. If data cannot be obtained, the team intends to use the data collected in 2012 by the Secretariat of Basel Convention in the project" use and -end -of-life of electrical and electronic equipment.(This document does not have data needed in this report. The data reflected in that report are list of importer of EEE, types and quantities of EEE in government ministries and agencies and types and quantities EEE in household) In case of lack of data even these data (mentioned quanitites of EEE) can be utilized for the estimation. In case of lack of data even these data (mentioned quanitites of EEE) can be utilized for the estimation.

Detailed inventory of c-OctaBDE in the Republic of Liberia

Liberia is a developing country with weak regulatory system. Inventory was done for POP- PBDEs on stock in households and public areas and commercial sector such as CRT, TV and PC monitors and waste from EEE manufactured before 2004 since indeed they are the main source of the PBDEs chemical. For the transport sector, vehicles (small cars, trucks, yellow machines, buses) produced before 2004, and their countries of origin were assessed. The table below shows quantities of EEE used in 6 selected Ministries and Agencies.

The most relevant data on PBDE (c-OctaBDE}, the distribution of c-OctaBDE and the principal constituents in electrical materials are from 2012, as the condition/situation in Liberia did not allow further identification of the existing quantites of PBDEs.

Table 11a Quantities of EEE used in 6 selected Ministries and Agencies

DESCRIPTION	**INSTITUTIONS AND NUMBER OF EEE/INSTITUTION**						
	Ministry of Youth & Sports	**LIGIS**	**Ministry of Agriculture**	**Ministry of Health**	**EPA**	**NEC**	**Total**
Desktops	0	0	0	5	1	2	8
Laptops	0	0	0	1	0	0	1
Printers							

Televisions	0	0	0	0	0	0	0
Fridges	0	2	0	4	0	0	6
Air Conditioners	0	0	0	0	0	0	0
Desks	2	0	0	5	0	0	7

The table below shows quantities of EEE used in four(4) non- governmental Agencies produced before and in 2004

Table 11b Quantities of EEE used in four(4) non- governmental Agencies produced before and in 2004

Description	**Name of institution and No. of EEE per institution**				
	Underground Water	**Equipment Liberia**	**Firestone Liberia**	**Paynesville Central Academy**	**Total**
Desktop	0	0	0	2	2
Laptops	0	0	0	0	0
Printers	1	0	0	0	0
Television	0	0	0	0	0

Table 11c Type and quantities of EEE used in 5 selected Ministries and Agencies of Government

DESRIPTION	**INSTITUTIONS AND NUMBER OF EEE/INSTITUTION**						
	Ministry of Youth & Sports	**LIGIS**	**Ministry of Agricultur e**	**Ministry of Health**	**EPA**	**NEC**	**Tota l**
No. of Employees	X	212	300	500	146	205	1,363
Desktops	X	147	43	105	25	100	420
Laptops	X	42	100	111	25	40	318
Printers	X	25	52	98	31	75	281
Televisions	X	5	10	12	3	7	37
Fridges	X	2	12	79	5	15	113

Air Conditioners	X	22	61	89	25	22	219
Desks	x	x	x	x	x	x	x

This table was formulated in the project "e-waste country Liberia" during the e-waste Africa Project of the Secretariat of the Basel Convention in 2012.

Table 11d Type and Quantities of EEE not in use in 5 selected Government Ministries & Agencies

DESRIPTION	**INSTITUTIONS AND NUMBER OF EEE/INSTITUTION**						
	Ministry of Youth & Sports	LIGIS	Ministry of Agriculture	Ministry of Health	EPA	NEC	Total
No. of Employees	X	212	300	500	146	205	1,363
Desktops	X	34	8	11	15	16	84
Laptops	X	19	7	91	6	7	47
Printers	X	16	11	9	21	18	75
Televisions	X	4	4	9	1	8	26
Fridges	X	7	4	7	0	6	24
Air Conditioners	X	12	17	12	7	14	62
Desks	x	x	x	x	x	x	x

This table was formulated in the project "e-waste country Liberia" during the e-waste Africa Project of the Secretariat of the Basel Convention in 2012.

All of the government ministries and agencies were interviewed could not produce realistic statistical data on electrical and electronic equipment in use or used and dispose of .Hence, table 11c and table 11d were developed from the work of a group of experts who conducted similar survey in 2012 under the sponsorship of the Basel Convention. The report indicated the countries from which the EEE were imported but did not mention the manufacturing date of the equipment.

9. Inventory of POPs-PFOS

The extent of the POPs- PFOS inventory was to discover the presence and use of PFOS chemicals in the industrial sector and products we use every day in Liberia. The aim is to prioritize industrial sectors and the applications of these chemicals in Liberia (if they do exist) to obtain preliminary and possibly detailed quantities on stock, in use and in the waste stream following the "life cycle" of the chemicals, to identify potential contaminated hot spots, and to determine whether there are PFOS present in our country.

The major challenge was obtaining the needed information/data from the industrial sectors in Liberia. Having read about the wide range of application of PFOS and its related substances in the industrial sectors, the team targeted four industrial sectors where the application of PFOS could be seen. Industrial sectors considered are:

- ✓ Firefighting foams
- ✓ Production of pulp and paper
- ✓ Metal plating industries and
- ✓ Production of construction and insolating materials

Accordingly, questionnaires were prepared and distributed to companies, ministries/agencies and institutions from the industrial sectors that are expected to have some level of PFOS application. Firefighting foams, for example, are not produced but are imported in the country. Hence, the team paid an assessment visit to the Liberia National Fire Service to ascertain the types firefighting materials available.

Results of the PFOS inventory

The firefighting materials used by the Liberia National Fire Service are well labeled. The labels show no presence of PFOS and its salts except where the labels are fraudulently used to deceive the consuming public. This is another challenge where the local experts lack the capacity to detect chemicals under investigation.

Firefighting foams from the Liberia National Fire Service.

Figure 11. Aqueous film forming foams (AFFF) and Hi-COMBATA Class A both produced by ANGUS

The unwillingness of the few industries, operating in Liberia, to release information/data pertain to chemicals make it extremely difficult for PFOS and PFOS containing materials to be quantified. Questionnaires distributed three months ago are yet to be returned.

Inventory of Pentachlorobenzene (Pecb)

From assessment and interview, the team believes that intentional anthropogenic source of PeCB poses no threat to Liberia situation owing to the fact that chemicals production is not popular in Liberia. However, the team strongly believes that un-intentional point sources are found in Liberia due to unsystematic burning of unsegregated solid waste in Liberia as evident from the figures shown below.

Figure 12 Scenes of Whein Town where all the solid wastes in Monrovia and its environs are disposed off.

During the dry season the waste are set a blaze either intentionally or by spontaneous combustion.

10. REVIEW AND UPDATE OF THE INVENTORY OF RELEASES FROM THE UNINTENTIONAL PRODUCTION OF ANNEX C CHEMICALS (PCDD, PCDF, PCB, HCB AND PeCB)

Under the Stockholm Convention on Persistent Organic Pollutants (POPs), Parties are required to reduce total releases from anthropogenic sources of the chemicals listed in Annex C with the goal of continually minimizing and, where feasible, ultimately eliminating releases of these unintentionally produced chemicals. Toward this end, Parties must develop action plans as part of their National Implementation Plans (NIP) to identify, characterize and address the releases of unintentional POPs listed in Annex C. Action plans to be developed according to Article 5 of the Convention shall include evaluations of current and projected releases that are derived through the development and maintenance of source inventories and release estimates, taking into consideration the source categories listed in Annex C.

To achieve the goal of the Convention, Parties are required to implement or promote **best available techniques (BAT) and best environmental practices (BEP), as described in the "Guidelines on Best Available Techniques and Provisional Guidance on Best Environmental Practices relevant to Article 5 and Annex C of the Stockholm Convention on Persistent Organic Pollutants".**

Five years after developing their action plan, Parties are required to review their adopted strategies, including the extent to which their unintentional POPs releases have been reduced, and to incorporate such reviews in national reports pursuant to Article 15.

It is thus within this context that this update has been undertaken in Liberia.

Pursuant to Article 5 of the Convention, the following unintentional POPs are listed in Annex C:

Polychlorinated dibenzo-*p*-dioxins (PCDD)

Polychlorinated dibenzofurans (PCDF),

Polychlorinated biphenyls (PCB),

Hexachlorobenzene (HCB), and

Pentachlorobenzene (PeCBz) [6]

Among these, PCDD and PCDF (also collectively referred to as PCDD/PCDF or dioxins) have never been used as commercial products, nor were intentionally manufactured for any reason other than laboratory purposes. PCB, HCB and PeCBz are also unintentionally formed, usually from the same sources that produce PCDD/PCDF. However, unlike PCDD/PCDF, they have also been manufactured and used for specific purposes, their intentional production and use being by far higher than their unintentional formation and release.

PCDD/PCDF releases are accompanied by releases of other unintentional POPs, which can be minimized or eliminated by the same measures that are used to address PCDD/PCDF releases. When a comprehensive inventory of PCDD/PCDF is elaborated, it enables the systematic

[1] Annex C was amended to include pentachlorobenzene at the fourth meeting of the Conference of the Parties, held from 4 to 8 May 2009, by decision SC-4/16.

identification of priority sources, the formulation of appropriate measures and development of action plans to minimize, or where feasible, eliminate the releases **of all unintentional POPs**.

It is thus recommended, for practical reasons, that inventory activities be focused on PCDD/PCDF, as these substances are **indicative of the presence of other unintentional POPs**. They are considered to constitute a sufficient basis for **identifying** and **prioritizing** sources of all such substances as well as for **devising applicable control measures for all Annex C POPs** and for **evaluating their efficacy**.

10.1 Inventory Methodology

To support Parties such as Liberia in meeting their obligations, a methodology has been developed to ensure that source inventories and release estimates are complete, transparent as well as consistent in format and content. It allows Parties to compare results, identify priorities, mark progress and follow changes over time at the national, regional and global levels.

The Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases was first published in 2003 and revised in 2005. In 2006, the Conference of the Parties to the Stockholm Convention welcomed the second Toolkit edition and recognized its usefulness. At the same time, Parties acknowledged the need for its ongoing revision and updating, placing emphasis on key sources for which limited data were available and on providing support to developing countries such as Liberia in their efforts to verify their emission factors. Parties also requested overall improvement of the usefulness and user-friendliness of the Toolkit.

The Toolkit is the most comprehensive available compilation of emission factors for all relevant PCDD/PCDF sources. It is useful particularly in countries such as Liberia where measurement data are limited, enabling the elaboration of source inventories and release estimates by using the default emission factors. It is also useful in countries where national measurement data are available, as a reference document for data comparison and validation purposes.

The Conference of the Parties at its fifth meeting in 2011 welcomed these revisions and updates, and Parties were encouraged to use the additional guidance.

In addition to emission factors for PCDD/PCDF, the Toolkit also contains emission factors for other POPs when such information is available. ***Usually, emission factors are provided for the following five release vectors: air (EF_{Air}), water (EF_{Water}), land (EF_{Land}), product ($EF_{Product}$), and residue ($EF_{Residue}$)***. The current UNEP toolkit does not address the releases of PCBs and HCB as unintentionally produced POPs.

The utilization of the **UNEP Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases (Toolkit 2013)** greatly aided the current revision and update of the inventory of dioxin (UPOPs) releases in Liberia.

POPs Releases from Sources

Sources of POPs releases are of four general types, three of which are active, ongoing processes, and one is a legacy of historic activities:

Chemical production processes, *e.g.*, facilities or production units that produce chlorinated phenols or in which certain other chlorinated chemicals are manufactured, or that produce pulp and paper using elemental chlorine for chemical bleaching;

Thermal and combustion processes, *e.g.,* waste incineration, combustion of solid and liquid fuels, or production of metals in thermal processes;

Biogenic processes in which PCDD/PCDF may be formed from precursors – manufactured chemicals such as pentachlorophenol that are structurally closely related precursors of PCDD/PCDF.

Reservoir sources such as historic dumps containing PCDD/PCDF and other POPs-contaminated wastes, and soils and sediments in which POPs have accumulated over time.

The Toolkit presents information on each of the unintentional POPs source categories listed in Annex C, some additional source categories, and a strategy for identifying new source categories. It describes a step-by-step process to estimate PCDD/PCDF releases from each source category to the following environmental media:

- ***Air***,
- ***Water*** (surface and ground water, including marine and estuarine water as well as sediments), and
- ***Land*** (surface soils),

also to these process outputs:

- ***Products*** (such as chemical formulations, including pesticides or consumer goods such as paper, textiles, etc.);
- ***Residues*** (including certain liquid wastes, sludge, and solid residues, which are handled and disposed of as waste or may be recycled).

Application of Toxic Equivalents (TEQ)

Taken as a whole, PCDD and PCDF are a group of 210 tricyclic, chlorine-containing aromatic chemicals; there are 75 congeners of PCDD and 135 congeners of PCDF possible. PCDD and PCDF typically occur as mixtures. The most toxic compounds have chlorines in the 2, 3, 7 and 8 positions; they have been assigned a toxicity equivalency factor (TEF) based on the relative potency of each congener in comparison to the most toxic congener, 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD). In total, there are 17 congeners in which chlorine atoms occur at the 2, 3, 7, and 8 positions. ***Mixtures of these 17 congeners are often evaluated and reported as a single number called toxic equivalent (TEQ)***. To determine the TEQ of a mixture, the mass concentration of each congener is analytically determined, multiplied by the assigned TEF, and the products summed. The first scheme, derived by the Committee on the Challenges of Modern Society of the North Atlantic Treaty Organization in 1988 and called I-TEFs, covered 17 PCDD/PCDF. Subsequent revisions of TEFs were coordinated by the World Health Organization (WHO) in 1997 and 2005. These revisions also included 12 dioxin-like polychlorinated biphenyls (dl-PCB). For PCB, the compounds having the highest toxicity are those in which the molecule can assume a planar configuration, analogous to that of PCDD/PCDF.

To estimate PCDD/PCDF releases in inventories, the Convention requires that the most advanced TEFs are used. These are, at present, the WHO-TEFs established by a WHO/IPCS expert meeting in 2005. However, the Conference of the Parties have not yet recognized or adopted these.

Inventory Limitations

An inventory can provide valuable information on the magnitude of releases to each environmental medium and in products and residues. It can highlight sources for possible impacts but it cannot provide an accurate guide to the relative impact of these releases on human or ecosystem exposure since the fate of PCDD/PCDF varies considerably from one release source to another. ***The main purpose of an inventory is to identify sources of unintentional POPs (UPOPs), prioritize them and undertake measures to prevent the formation and reduce or eliminate releases of unintentional POPs. Furthermore, measures taken to address PCDD/PCDF releases are equally suitable for other unintentional POPs***.

Identifying Sources and Estimating Releases of PCDD/PCDF

The PCDD/PCDF inventory includes these five steps:

- Identify sources;
- Select emission factors for the identified sources;
- Assign activity rates for each of the identified sources;
- Multiply the emission factors by the activity rates;
- Compile the inventory.

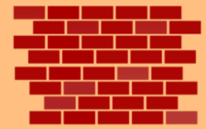
Identifying Sources

To assist Parties in identifying PCDD/PCDF sources at the national level, the Toolkit includes source categories as described in Annex C of the Stockholm Convention, Parts II and III. Since the list in Part III is indicative and open for additions, the Toolkit also contains further source categories that have been identified in existing inventories, national assessments, scientific studies, etc. In addition, it provides a simple screening process for identifying other sources not yet listed in the Toolkit.

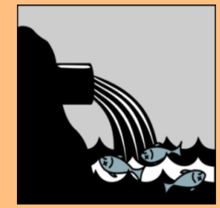
Sources listed in the Toolkit

A country or region can begin identifying its PCDD/PCDF sources by determining the presence or absence within its borders of the PCDD/PCDF sources currently listed in the Toolkit. The Toolkit lists the source categories identified in Annex C as well as those identified by other means such as national PCDD/PCDF inventories, scientific studies and reports.
The source categories listed in the Toolkit are divided into ten source groups. Table 1 presents these ten source groups and the source categories currently listed in the Toolkit.

Table 22- Source Groups and Associated Source Categories

Table 12 – Source Groups and Associated Source Categories						
Source Group		**1 - Waste Incineration** 	**2 - Metal Production** 	**3 - Heat and Power Generation** 	**4 - Production of Mineral Products** 	**5 - Transport** 
Source Categories	**a**	Municipal solid waste incineration	Iron ore sintering	Fossil fuel power plants	Cement production	4-Stroke engines
	b	Hazardous waste incineration	Coke production	Biomass power plants	Lime production	2-Stroke engines
	c	Medical waste incineration	Iron and steel production and foundries	Landfill Biogas combustion	Brick production	Diesel engines
	d	Light-fraction shredder waste incineration	Copper production	Household heating and cooking (biomass)	Glass production	Heavy fuel oil (HFO)-fired engines
	e	Sewage sludge incineration	Aluminum production	Domestic heating (fossil fuels)	Ceramics production	
	f	Waste wood and waste biomass incineration	Lead production		Asphalt Mixing	
	g	Destruction of animal carcasses	Zinc production		Oil Shale Processing	
	h		Brass and bronze production			
	i		Magnesium production			

	j		Other non-ferrous metal production				
	k		Shredders				
	l		Thermal wire reclamation				

Source Group		6 - Open Burning Processes 	7 - Chemicals and Consumer Goods 	8 - Miscellaneous 	9 - Disposal 	10 - Hot Spots 
Source Categories	a	Biomass burning	Pulp and paper production	Drying of biomass	Landfills, waste dumps and landfill mining	Sites used for the production of chlorine
	b	Waste burning and accidental fires	Chlorinated inorganic chemicals	Crematoria	Sewage/ sewage treatment	Production sites of chlorinated organics
	c		Chlorinated aliphatic chemicals	Smoke houses	Open water dumping	Application sites of PCDD/PCDF containing pesticides and chemicals
	d		Chlorinated aromatic chemicals	Dry cleaning	Composting	Timber manufacture and treatment sites
	e		Other chlorinated and non-chlorinated chemicals	Tobacco smoking	Waste oil treatment(non-thermal)	Textile and leather factories
	f		Petroleum industry			Use of PCB
	g		Textile production			Use of chlorine for production of metals and inorganic chemicals

	h		Leather refining			Waste incinerators
	i					Metal industries
	j					Fire accidents
	k					Dredging of sediments and contaminated flood plains
	l					Dumps of wastes/residues from source groups 1-9
	m					Kaolin or ball clay sites

Activity Rates

Activity rates are values in unit per year of product manufactured (*e.g.*, steel, sinter, cement, pulp, compost, *etc.*) or feed material processed (*e.g.*, municipal waste, hazardous waste, coal, diesel fuel, bodies cremated, *etc.*), or annual quantities of material released (*e.g.*, *cubic meters* of flue gas, liters of wastewater, kilograms or tons of sludge generated, *etc.*).

Values for activity rates may be found in centralized statistical information assembled by state, provincial, national or international agencies, and they may be obtained from trade associations and owners or operators of facilities. Potential sources of information on activity rates include the following:

- National statistics;
- National energy balance;
- Regional economic activity records including national production and import/export data;
- International statistics such as EUROSTAT, OECD, FAO, World Bank, etc.
- Local operating and permitting records of industrial facilities;
- Industry association data;
- Historical production and industry data;
- Other release inventories such as the inventory of criteria pollutants and /or greenhouse gases;
- Questionnaires;
- Pollution Release and Transfer Registers (PRTRs).

When the activity rate for an industrial source category is not available but the nameplate capacity is known, an activity rate can be estimated by multiplying capacity by the domestic capacity utilization factor (CUF). If no domestic CUF is available, a regional or global CUF may be used and, if neither regional nor global CUF is available, the Toolkit Expert Group may provide an appropriate value.

Activity rates for diffuse source categories, such as traffic, open burning of domestic waste, agricultural residues, etc., are best characterized by drawing from centrally available data.

Release Estimates

Once PCDD/PCDF sources are identified and classified, emission factors selected and national or regional activity rates determined, the estimation of the total annual releases by source group, source category and class is relatively simple and straightforward.

***For a source class,* PCDD/PCDF releases per year are calculated according to the equation below. The activity rate is multiplied by each of the five emission factors and the sum of the five resulting values represents the quantity of PCDD/PCDF released annually from the source class.**

PCDD/PCDF released, grams TEQ/year (gTEQ/a) = Activity Rate x Emission Factor$_{Air}$ (ARxEF$_{Air}$)+ Activity Rate x Emission Factor$_{Wate}$r (ARxEF$_{Water}$)+ Activity Rate x Emission

Factor$_{Land}$ (ARxEF$_{Land}$)+ Activity Rate x Emission Factor$_{Product}$ (ARxEF$_{Product}$)+ Activity Rate x Emission Factor$_{Residue}$ (ARxEF$_{Residue}$).

For a source category, the annual PCDD/PCDF release is calculated as the sum of the total annual releases for each source class within the source category.

For each source group, the annual PCDD/PCDF release is the sum of the annual releases calculated for each source category in the source group.

For a country or region, the total annual PCDD/PCDF release is the sum of the annual releases from all source groups.

The spreadsheet is used to determine annual releases according to source groups and the reporting year; in the case of Liberia, 2004 (the initial inventory year) and 2014 (the revision and updating year), with the aid of Toolkit 2013.

Compilation of the PCDD/PCDF Inventory

The Toolkit simplifies and expedites the calculations described above by providing an Excel spreadsheet that includes a list of the source categories addressed in the Toolkit, along with their associated classes and accompanying default emission factors. Once the activity rates for all classes within the source categories that have been determined to be present within a country or region are entered into the spreadsheet, annual PCDD/PCDF releases are automatically calculated for each source category. A summarizing worksheet provides an overview of all releases according to vectors (air, water, land, product and residue) and source groups.

Newly identified sources can also be included in the spreadsheet, along with their associated emission factors and activity rates. Their releases are also automatically calculated and included in the final results. If desired, a country can replace the Toolkit's default emission factors with their own emission factors that have been otherwise derived.

Categorization of Sources

Source categories of unintentional POPs releases under the Stockholm Convention are listed in Annex C Part II and Part III to the Convention. These source categories are also among those considered in the Toolkit, where they are placed into ten source groups to facilitate the development of national release inventories and reporting of POPs releases.

The standard format to report PCDD/PCDF releases through national reports under Article 15 is included in Table 13 below.

Table 13- Annual Releases of PCDD/PCDF (g TEQ/a) YEAR

Source group	**Table 2 - Annual Releases of PCDD/PCDF (g TEQ/a) YEAR**				
	Air	**Water**	**Land**	**Product**	**Residue**
1.Waste incineration					
2.Ferrous and non-ferrous metal production					

3.Heat and power generation					
4.Production of mineral products					
5.Transportation					
6.Open burning processes					
7.Production of chemicals and consumer goods					
8. Miscellaneous					
9. Waste disposal					
TOTAL	0	0	0	0	0

Parties are encouraged to report releases of unintentional POPs in national reports submitted pursuant to Article 15 of the Convention, according to the source categories listed in Annex C of the Convention, grouped into the source groups specified in the Toolkit. By complying with this approach, Parties will ensure that the following conditions are met:

- Estimates of unintentional POPs releases are readily comparable;
- Regional and global release summaries can be easily prepared; and
- Time trends can be readily elaborated for the purpose of effectiveness evaluation under Article 16 of the Convention.

Baseline Release Estimates, Updating, Revisions and Projections

Article 5, paragraph (a) (i) of the Stockholm Convention requires that Parties evaluate current and projected releases, including the development and maintenance of source inventories and release estimates of chemicals listed in Annex C, Part I, taking into consideration the source categories identified in Annex C, Part II and III, of the Convention.

In practice, this means that Parties must prepare their initial release estimates and update these estimates at regular intervals (*e.g.* every five years). Parties may also find it necessary to revise their initial and subsequent estimates in order to establish and maintain the consistency necessary for discerning meaningful trends in releases over time.

The baseline release estimate is the first inventory of sources and releases of Annex C POPs elaborated by a Party, usually as part of the National Implementation Plan developed under Article 7. This first inventory serves as a baseline against which subsequent updated release estimates are assessed in order to establish trends in releases over time and evaluate the effectiveness of the adopted strategies for minimizing, or where feasible, eliminating PCDD/PCDF and other unintentional POPs releases.

Updating and revising an inventory begins with an examination of the previous or baseline inventory to identify the approach used, including:

- The classification of sources and emission factors used;
- Information sources based on which activity rates were estimated; and,
- Assumptions and expert judgment applied to fill the gaps.

In a second step, changes in data since the baseline inventory are reviewed, particularly by checking for factors that may influence changes in releases over time such as economic or demographic growth, changes in technologies in particular through phasing in BAT and BEP, building, reconstruction or decommissioning of production facilities, substitution of fuels, introduction of abatement techniques, identification of new sources, and others.

It is also important to check whether new or revised emission factors have become available or new source categories or classes have been included in the Toolkit (e.g. Toolkit 2013 Revised). Once these data and information are collected, the sources are reclassified to reflect the current situation in the particular reference year and with the establishment of activity rates for the reference year (2014 in Liberia).

Once the information is assessed and the inventory is updated to reflect economic, demographic and technical changes, the need to revise the previous inventories, including the baseline, may arise. Revising previous inventories so that new or revised emission factors and new source categories and classes are incorporated is especially important.

Besides such changes in the Toolkit methodology, some specific national factors may also trigger the need for revision. These are usually related to the availability at the country level of new or corrected information/knowledge, *e.g.* correction of past activity estimates or the discovery of sources that existed in the past but were not considered in previous inventories due to lack of adequate information at that time.

The revision of the previous inventories aims to correct the estimates therein, by including missing information, filling gaps, using the same set of emission factors, applying the same assumptions, expert judgment ***as in the updated inventory***.

Only after this stage, updated releases are calculated and consistent trends in releases over time are established. If sources are reclassified and/or emission factors have been revised, new factors must be assigned accordingly; if the source classification has not changed, nor the emission factors, the same factors are applied; releases are finally estimated by multiplying the emission factors by the corresponding activity rates.

Maintaining all these stages in the inventory updating and revision process is essential to ensure that coherent trends over time can be computed based on comparable and

consistent results over time. The same approach needs to be applied consistently in all release estimates to ensure consistency of results over time and to enable the assessment of trends over time.

If the approach changes over time, new or corrected information or knowledge becomes available at the country level, previous inventories can be revised accordingly and ***a single approach used for all inventories.*** Otherwise, it would not be possible to compare data from the different reference years and establish consistent trends over time.

Projections of future release estimates may be elaborated by Parties using the same methodology, by considering:

- Appropriate emission factors based on planned or expected changes in technologies, raw materials, fuels, abatement techniques or other key parameters which could influence release estimates (*e.g.* triggered by the action plan developed under Article 5 of the Convention).

- Projections of future activity rates for certain source categories based on, say, expected socio-economic development, production plans for a particular source category or source group, etc.

Data Quality

Source inventories and release estimates reported under Article 15 are required to be:

- Reliable,
- Consistent over time,
- Comparable between countries,
- Transparent, and
- Complete.

Reliable inventories entail coherent application of internationally acknowledged methodologies such as the Toolkit and the use of best available national information.

To achieve consistency over time, the same approach should be used over time to establish consistent time trends. To ensure comparability between countries, all countries should report according to the same source groups and source categorization.

For transparent estimates, the approach, methodology, information, and assumptions used should be clearly described, documented and archived to facilitate inventory updates in the future.

For complete release inventories, all relevant source categories, all sources within those categories and all relevant release vectors have to be considered in the whole country. The inventory should also include information on source categories that do not exist or are not operational in the country during the reference year.

The single most important challenge associated with an inventory of this sort is data collection and availability, especially in the Liberian context.

Quality Assurance and Quality Control (QA/QC)

The following quality assurance and quality control measures (QA/QC) should be applied to ensure that the source inventory and release estimates meet the data quality criteria described above:

- Activity Rates;
- Aligning the unit of the activity rate with the unit of the emission factor;
- Paying attention to orders of magnitude while recalculating the activity rates and applying the emission factors;
- Explaining clearly and completely all assumptions made in filling gaps in activity rates; and,
- Explaining clearly and completely the process of classification of sources and the way activity rates were derived.

Qualifiers such as ***high, medium and low level of confidence (LoC)*** may be applied to both emission factors and activity data to determine the overall confidence in the inventory's results. Quality ranks are assigned to default emission factors by the Toolkit expert group to enable informed use of the methodology to assess PCDD/PCDF releases.

10.2 Releases from Unintentional Production of Annex C Chemicals (PCDD, PCDF, PCB, HCB and PeCB)

Summary of Results

This section summarizes the revised and updated inventory results, obtained utilizing Toolkit 2013.

Revised Inventory Results 2004

Table 14 (a) Revised Inventory Results 2004

Group	***Source Groups***	***Annual Releases (g TEQ/a)***				
		Air	***Water***	***Land***	***Product***	***Residue***
1	Waste Incineration	0.600	0.000	0.000	0.000	0.003
2	Ferrous and Non-Ferrous Metal Production	0.019	0.000	0.000	0.000	0.038
3	Heat and Power Generation	3.000	0.000	0.000	0.000	0.212
4	Production of Mineral Products	0.000	0.000	0.000	0.000	0.000
5	Transportation	0.309	0.000	0.000	0.000	0.000
6	Open Burning Processes	38.535	0.000	1.316	0.000	0.000

7	Production of Chemicals and Consumer Goods	0.000	0.000	0.000	0.000	0.000
8	Miscellaneous	0.001	0.000	0.000	0.000	0.001
9	Disposal	0.000	0.548	0.000	0.000	0.000
10	Identification of Potential Hot-Spots				0.000	0.000
1-10	***Total***	***42.463***	***0.548***	***1.316***	***0.000***	***0.253***
Grand Total		***45***				

Open burning of domestic and agricultural waste is by far the single most important source of UPOPs releases to air and land, while untreated domestic waste water is the only known significant source of UPOPs releases to water.

Table 14 (b) Initial Inventory Results 2004[7]

Source Group	***source categories***	***Air***	***Water***	***Land***	***Products***	***Residue***
1	Waste incineration	0.6				
2	Ferrous and non-ferrous metal production	0.03				0.08
3	Power generation and heating	3.0				0.6
4	Production of minerals					
5	Transport	0.35				
6	Uncontrolled combustion processes	182.5		7.5		120
7	Production/use of chemicals and consumer goods					
8	Miscellaneous	0.04				
9	Disposal /landfill	0.04	0.55			
1-10	TOTAL (g TEQ/a)	259.1	547.5	10.0	0.0	450.7

[7] This table contains the previous or initial inventory results. A number of errors were rectified during the revision calculations.

Updated Inventory Results

Table 15 Updated Inventory Results

Group	Source Groups	Annual Releases (g TEQ/a)				
		Air	Water	Land	Product	Residue
1	Waste Incineration	0.739	0.000	0.000	0.000	0.004
2	Ferrous and Non-Ferrous Metal Production	0.023	0.000	0.000	0.000	0.047
3	Heat and Power Generation	3.693	0.000	0.000	0.000	0.261
4	Production of Mineral Products	0.000	0.000	0.000	0.000	0.000
5	Transportation	0.380	0.000	0.000	0.000	0.000
6	Open Burning Processes	47.437	0.000	1.619	0.000	0.000
7	Production of Chemicals and Consumer Goods	0.000	0.000	0.000	0.000	0.000
8	Miscellaneous	0.001	0.000	0.000	0.000	0.001
9	Disposal	0.000	0.674	0.000	0.000	0.000
10	Identification of Potential Hot-Spots				0.000	0.000
1-10	**Total**	**52.272**	**0.674**	**1.619**	**0.000**	**0.312**
Grand Total		**55**				

Open burning of domestic and agricultural waste is by far the single most important source of UPOPs releases to air and land, while untreated domestic waste water is the only known significant source of UPOPs releases to water.

10.3 Detailed Inventory Calculations

Revised Inventory
Source Group 1 – Waste Incineration

Medical waste incineration

Liberia had 6 kiln incinerators for medical waste, with the maximum capacity estimated to be 15ton/year. Medical waste incineration in Liberia entails uncontrolled batch combustion without air pollution control (APC) system.

There is no change in emission factors in the 2013 Toolkit. The source class emission factors in this case are 40,000 µg TEQ/t for air and 200 µg TEQ/t for residue (bottom ash). The annual releases of dioxins due to waste incineration are 0.600gTEQ/a to air and 0.003gTEQ/a to residue (bottom ash).

Table 16-Medical Waste Incineration

***Source* category class**	***Potential Release Route (µg TEQ/t)***						***Production t/a***	***Annual release***					
	Air	***Water***	***Land***	***Production***	***Residue***			***g TEQ/a***	***g TEQ/a***	***g TEQ/a***	***g TEQ/a***	***g TEQ/a***	***g TEQ/a***
					Fly Ash	***Bottom Ash***		***Air***	***Water***	***Land***	***Product***	***Fly ash***	***Bottom Ash***
Medical waste incineration							15	0.600	0	0	0	0.000	0.003
Uncontrolled batch combustion, no APCS	40,000		NA	NA		200	15	0.600				0.000	0.003

There are no activities in Liberia that pertain to the other source categories and their classes in source group 1 – Waste Incineration (See Table 1).

Source Group 2 - Ferrous and Non-Ferrous Metal Production

Aluminum Production

Only this source category is relevant in Liberia with a few secondary aluminum factories, which use thermal processing of scraps, with minimal treatment of inputs and simple dust removal. Their production was estimated to be 190 tons/year. The air emission factor has been dropped to100 µgTEQ/t from 150 µg TEQ/t and that for residue from 400 µgTEQ/t to 200 µgTEQ/t.

Table 17-Aluminum Production

***Source** category class*	*Potential Release Route (µg TEQ/t)*					*Production t/a*	*Annual release*				
	Air	*Water*	*Land*	*Product*	*Residue*		*g TEQ/a*	*g TEQ/a*	*g TEQ/a*	*g TEQ/a*	*g TEQ/a*
Ferrous and Non-Ferrous Metal Production							Air	Water	Land	Product	Residue
Aluminum production						190	0.019	0.000	0.000	0.000	0.038
Processing scrap Al, minimal treatment of inputs, simple dust removal	100	ND	NA	NA	200		0.019	0.000	0.000	0.000	0.038

The emission to air has decreased from 0.029 µgTEQ/t to 0.019 µgTEQ/t and that to residue from 0.076µg TEQ/t to 0.038 µgTEQ/t.

Source Group 3 - Power Generation and Heating

The emissions from these power generations are calculated under Category 5 (Transport), since the emission factors are comparable to those of combustion engines in vehicles.

Heavy fuel oil was not used for power generation in Liberia.

The majority of people used firewood or charcoal for domestic cooking. The estimated consumption of wood used directly for cooking or converted to charcoal was 2 million tons per year (2004 estimate). Assuming an average heating value of 15 MJ/kg, the total heat production would amount to 30,000 TJ/year.

Table 18-Household Heating and Cooking -- Biomass Fuel

***Source** category class*	*Potential Release Route (µg TEQ/TJ)*					*Production TJ/a*	*Annual release*				
	Air	*Water*	*Land*	*Product*	*Residue (Ash)*		*g TEQ/a*	*g TEQ/a*	*g TEQ/a*	*g TEQ/a*	*g TEQ/a*
Heat and Power Generation							***Air***	***Water***	***Land***	***Product***	***Residue***
Household heating and cooking - Biomass						**30,000**	**3.000**	**0**	**0**	**0**	**0.212**
Virgin wood/biomass-	10	ND	ND	NA	10	21,090	**2.10**				**0.211**

fired stoves	0						9				
Charcoal-fired stoves	100	ND	ND	NA	0.1	8,910	**0.891**				**0.001**

Source Group 4: Mineral Productions

Cement Production

The only cement plant in Liberia, Cemenco, imported and still imports its inputs already processed for mixing.

Lime Production

There is no lime production in Liberia.

Brick Production

There was no brick production during the baseline inventory.

Glass Production

There was no glass production during the baseline inventory.

Ceramics Production

There was none during the baseline.

Asphalt Mixing

In 2005, 800 m^3 of asphalt was reportedly imported into the country; the conversion ratio was 2.5 tons of asphalt to 1 m^3. The asphalt mixture is made on location with no air pollution control (APC) and at the temperature of 140^0C.

Table 19-Asphalt Mixing

***Source* categories/class**	***Potential Release Route (µg TEQ/t)***					***Production t/a***	***Annual release***				
	Air	***Water***	***Land***	***Product***	***Residue***		***g TEQ/a***	***g TEQ/a***	***g TEQ/a***	***g TEQ/a***	***g TEQ/a***
Production of Mineral Products							Air	Water	Land	Product	Residue
Asphalt mixing						2,000	0.000140	0.000000	0.000000	0.000000	0.000000
Mixing plant with no gas cleaning	0.07	NA	NA	ND	ND	2,000	0.000140				

No change in emission factor in the 2013 Toolkit regarding the source category of asphalt mixing.

Source Group 5: Transport

From 2004 import data it was estimated that 120,000 tons of leaded fuels and 1,400 tons of unleaded fuel were used in 4-stroke engines. About 2,400 tons of leaded fuel was used in 2-stroke engines. According to the data from National Fire Service, in 2004, about 360,500 tons of diesel fuel was imported for transport of all kinds, fishing vessels and power generation. No heavy fuel oil was used.

Table20-Transport

Source categories	***Potential Release Route (µg TEQ/t)***					***Consumption t/a*** [8]	***Annual release***				
	Air	***Water***	***Land***	***Product***	***Residue***		***g TEQ/a***	***g TEQ/a***	***g TEQ/a***	***g TEQ/a***	***g TEQ/a***
Transport							**Air**	**Water**	**Land**	**Product**	**Residue**
4-Stroke engines						**121,400**	**0.264**	**0.000**	**0.000**	**0.000**	**0.000**
Leaded fuel	2.2	NA	NA	NA	NA	120,000	**0.264**				
Unleaded gasoline without catalyst	0.1	NA	NA	NA	NA	1,400	**0.000**				
2-Stroke engines						**2,400**	**0.008**		**0**	**0**	**0**
Leaded fuel	3.5	NA	NA	NA	NA	2,400	**0.008**				
Unleaded fuel	2.5	NA	NA	NA	NA	0	**0.000**				
Diesel engines						**360,500**	**0.036**	**0.000**	**0.000**	**0.000**	**0.000**
Regular Diesel	0.1	NA	NA	NA	ND	360,500	**0.036**				
Transport							**0.309**	**0**	**0**	**0**	**0**

No change in emission factors in the 2013 Toolkit regarding the relevant transport source categories.

[8] Assume consumption equals sales.

Source Group 6: Uncontrolled combustion processes

Waste Burning and Accidental Fires

Bush and forest fires were not frequent in Liberia according to the Ministry of Agriculture (MOA). However, agricultural waste burning was and is still common. On the basis of an expert judgment, a conservative estimate of 1 million tons of biomass burnt was used for this calculation.Since no municipal waste incinerators exist in Liberia, household waste is burnt either domestically or elsewhere. For this calculation it has been assumed that 100 kg of solid waste per person per year are burnt in open air (2/3 at homes and 1/3 in elsewhere).

Accidental fire in houses and vehicles

In the absence of national fire data, assumed 150 fires per year in houses and 200 vehicle fires per year occurred, using the experience of similar countries in the region.[9]

Open domestic waste burning at West Point junction on December 28, 2011 in Monrovia, Liberia

[9] Assume approximately a ton of materials is consumed in each house fire event and 5 tons in each vehicle fire event.

Table 21: Uncontrolled Combustion Processes

Source categories	Potential Release Route (µg TEQ/t)					Production	Annual release				
	Air	Water	Land	Product	Residue	t/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a
Open Burning Processes							**Air**	**Water**	**Land**	**Product**	**Residue**
Biomass burning						**750,000**	**0.375**	**0**	**0.038**	**0**	**0**
Agricultural residue burning in the field of cereal and other crops stubble, not impacted	0.5	ND	0.05	NA	NA	750,000	**0.375**		**0.038**		
Waste burning and accidental fires						**301,150**	**38.160**	**0**	**1.278**	**0**	**0**
Fires at waste dumps (compacted, wet, high Corg content)	300	ND	10	NA	NA	100,000	**30.000**		**1.000**		
Accidental fires in houses, factories	400	ND	400	NA	NA	150	**0.060**		**0.060**		
Open burning of domestic waste[10]	40	ND	1	NA	NA	200,000	**8.000**		**0.200**		
Accidental fires in vehicles (per vehicle)	100	ND	18	NA	NA	1,000	**0.100**		**0.018**		
Open Burning Processes							**38.535**	**0**	**1.316**	**0**	**0.000**

Source Group 7: Production and use of chemicals and consumer goods

Activities in this source group were either irrelevant or produced very negligible footprint in respect of UPOPs releases.

[10] EFair (Toolkit 2003) is 300µgTEQ/t, while EFair (Toolkit 2013) is 40µgTEQ/t for open domestic waste burning.

Source Group 8: Miscellaneous

There are no crematoria in Liberia and only very few dry cleaners in the capital. Drying of biomass and smoking of fish are not practiced to any significant extent. Therefore the only activity to be considered in this category is tobacco smoking. Due to lack of actual record on smoking in the country, it was assumed that 500,000 persons smoked a pack of cigarette each a day and a pack weighs on average approximately one ounce (28.375 grams)[11].

Table 22: Tobacco Smoking

Source categories	Potential Release Route (µg TEQ/t)					**Production**	**Annual release**				
	Air	Water	Land	Production	Residue	**t/a**	**g TEQ/a**	**g TEQ/a**	**g TEQ/a**	**g TEQ/a**	**g TEQ/a**
Miscellaneous							**Air**	**Water**	**Land**	**Product**	**Residue**
Tobacco smoking						**5,178**	**0.0005**	**0**	**0**	**0**	**0.00052**
Cigarette (per million items)	0.1	NA	NA	NA	0.1	5,178	**0.0005**				**0.001**

[11] The weight of a package of cigarettes depends on a few different things. It will depend on the brand and if they are shorts or longs. Most packages weigh about one ounce (or $28.375x10^{-6}$t). Furthermore, the amount a carton of cigarettes weighs can vary, depending on brand, type and size of the cigarettes. Cigarettes come in varieties, like slims, wides and regulars. On average, a carton of cigarettes will weigh around 250 grams ($250x10^{-6}$t).

Source Group 9: Disposal/Landfill

Based on data from other countries in the region, the daily per capita generation of domestic wastewater was estimated at 100 liters (0.1ton/day). In urban areas this quantity is likely to be higher and in some places in the country it might be lower. Since Liberia does not have any wastewater treatment plants, 100% open dumping is assumed.[12]

Table 23: Disposal/Landfill

Source categories	Potential Release Route (μg TEQ/t)					**Production**	**Annual release**				
	Air	Water	Land	Product	Residue		**g TEQ/a**	**g TEQ/a**	**g TEQ/a**	**g TEQ/a**	**g TEQ/a**
Disposal							**Air**	**Water**	**Land**	**Product**	**Residue**
Open water dumping						**109,500,000**	**0.548**	**0.000**	**0.000**	**0.000**	**0.000**
Mixed domestic and industrial wastewater	NA	0.005	NA	NA	NA	109,500,000	**0.5475**	**0.000**			
Urban and peri-urban wastewater	NA	0.0002	NA	NA	NA		**0**	**0.000**			
Remote environments	NA	0.0001	NA	NA	NA		**0**	**0.000**			

[12] For 3 million people (2004 population estimate), the annual quantity of wastewater produced would be 0.1 tons x 365 x 3,000,000.

Source Group 10: Hot Spots

No hotspot was found. Moreover, hotspots for which emission factors are available in Toolkit 2013 do not exist in Liberia.

Table 24: Revised UPOPs Inventory – Annual Releases

Group	Source Groups	Annual Releases (g TEQ/a)				
		Air	Water	Land	Product	Residue
1	Waste Incineration	0.600	0.000	0.000	0.000	0.003
2	Ferrous and Non-Ferrous Metal Production	0.019	0.000	0.000	0.000	0.038
3	Heat and Power Generation	3.000	0.000	0.000	0.000	0.212
4	Production of Mineral Products	0.000	0.000	0.000	0.000	0.000
5	Transportation	0.309	0.000	0.000	0.000	0.000
6	Open Burning Processes	38.535	0.000	1.316	0.000	0.000
7	Production of Chemicals and Consumer Goods	0.000	0.000	0.000	0.000	0.000
8	Miscellaneous	0.001	0.000	0.000	0.000	0.001
9	Disposal	0.000	0.548	0.000	0.000	0.000
10	Identification of Potential Hot-Spots				0.000	0.000
1-10	***Total***	***42.463***	***0.548***	***1.316***	***0.000***	***0.253***
Grand Total		***45***				

Open burning of domestic and agricultural waste is by far the single most important source of UPOPs releases to air and land, while untreated domestic waste water is the only known significant source of UPOPs releases to water.

Appendix: Pictures from the open burning of waste sites

Picture 1- Open Burning near West Point junction on December 28, 2011

Picture 2 – Burning at West Point junction continued

Picture 2 - West Point junction continued

Picture 3 - West Point junction continued

Picture 4 – Burning at West Point junction continued

10.4 Updated Inventory

Population Statistics

The last census conducted in 2008 put the average annual population growth rate at 2.1%. In this updated inventory, this growth rate is used as a proxy to project increases in UPOP releases in the country. Since 2004 when the initial inventory was completed no program has been executed to reduce, or eliminate where feasible, UPOP releases. In other words, UPOP releases have been increasing due to increases in population from the time when the first inventory was carried out. An extrapolation based on this projection from 2004 to 2014, utilizing the average annual population growth rate of 2.1%, gave a common multiplier of 1.2309982. For instance, the activity rate of medical waste incineration (uncontrolled batch combustion with no air pollution control system) has risen from 15 tons per annum (2004) to about 18 tons per annum (2014)[13].

[13] Multiply 15 by 1.209982 (18.46497) and round it off to the nearest unit to obtain 18. This is easily done, using the Excel sheet.

Table 25 – Population Projection Based on 2008 National Population and Housing Census (NPHC)[14]

No.	***County***	***Population***											
		2004	***2005***	***2006***	***2007***	***2008***	***2009***	***2010***	***2011***	***2012***	***2013***	***2014***	***2015***
1	Bomi	77,409	79,035	80,694	82,389	84,119	85,885	87,689	89,531	91,411	93,330	95,290	97,291
2	Bong	306,880	313,324	319,904	326,622	333,481	340,484	347,634	354,935	362,388	369,998	377,768	385,701
3	Gbarpolu	76,736	78,348	79,993	81,673	83,388	85,139	86,927	88,753	90,616	92,519	94,462	96,446
4	Grand Bassa	204,009	208,293	212,667	217,133	221,693	226,349	231,102	235,955	240,910	245,969	251,135	256,408
5	Grand Cape Mount	116,939	119,395	121,902	124,462	127,076	129,745	132,469	135,251	138,091	140,991	143,952	146,975
6	Grand Gedeh	115,266	117,687	120,158	122,682	125,258	127,888	130,574	133,316	136,116	138,974	141,893	144,872
7	Grand Kru	53,293	54,413	55,555	56,722	57,913	59,129	60,371	61,639	62,933	64,255	65,604	66,982
8	Lofa	254,778	260,128	265,591	271,168	276,863	282,677	288,613	294,674	300,862	307,180	313,631	320,218
9	Margibi	193,178	197,234	201,376	205,605	209,923	214,331	218,832	223,428	228,120	232,910	237,801	242,795
10	Maryland	125,094	127,721	130,404	133,142	135,938	138,793	141,707	144,683	147,722	150,824	153,991	157,225

[14] According to the 2008 NPHC, the population growth rate is 2.1% per annum.

11	Montserrado	1,029,040	1,050,650	1,072,714	1,095,241	1,118,241	1,141,724	1,165,700	1,190,180	1,215,174	1,240,692	1,266,747	1,293,349
12	Nimba	425,171	434,099	443,215	452,523	462,026	471,729	481,635	491,749	502,076	512,620	523,385	534,376
13	River Cess	65,805	67,187	68,598	70,038	71,509	73,011	74,544	76,109	77,708	79,339	81,006	82,707
14	River Gee	61,461	62,752	64,070	65,415	66,789	68,192	69,624	71,086	72,578	74,103	75,659	77,248
15	Sinoe	94,223	96,202	98,222	100,285	102,391	104,541	106,737	108,978	111,267	113,603	115,989	118,425
Total		**3,199,284**	**3,266,469**	**3,335,065**	**3,405,101**	**3,476,608**	**3,549,617**	**3,624,159**	**3,700,266**	**3,777,972**	**3,857,309**	**3,938,313**	**4,021,017**

Source Group 1 – Waste Incineration

Medical waste incineration

Liberia had six (6) kiln incinerators for medical waste, with the maximum capacity estimated to be 15ton/year. Medical waste incineration in Liberia entails uncontrolled batch combustion without air pollution control (APC) system. There is no record of the construction of new incinerators, if any.

There is no change in emission factors in the 2013 Toolkit. The source class emission factors in this case are 40,000 µg TEQ/t for air and 200 µg TEQ/t for residue (bottom ash). The annual releases of dioxins due to waste incineration are 0.600gTEQ/a to air and 0.003gTEQ/a to residue (bottom ash).

There are no activities in Liberia that pertain to the other source categories and their classes in source group 1 – Waste Incineration (See Table 26).

Table26 Medical Waste Incineration

Source categories	Potential Release Route (µg TEQ/t)						Production	Annual release					
					Residue		t/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a
	Air	Water	Land	Product	Fly Ash	Bottom Ash		Air	Water	Land	Product	Fly ash	Bottom Ash
Waste incineration													
Medical waste incineration							**18**	**0.739**	**0**	**0**	**0**	**0.000**	**0.004**
Uncontrolled batch combustion, no APCS	40,000		NA	NA		200	18	**0.739**				**0.000**	**0.004**
Waste Incineration								**0.739**	**0**	**0**	**0**	**0.000**	**0.004**

Source Group 2 - Ferrous and Non-Ferrous Metal Production

Aluminum Production

Only this source category is relevant in Liberia with a few secondary aluminum factories, which use thermal processing of scraps, with minimal treatment of inputs and simple dust removal. Their production is projected to be 234 tons/year. The air emission factor has been dropped to100 µgTEQ/t from 150 µg TEQ/t and that for residue from 400 µgTEQ/t to 200 µgTEQ/t.

Table 27 Ferrous and Non-Ferrous Metal Production

Source categories	Potential Release Route (µg TEQ/t)					Production	Annual release				
	Air	Water	Land	Product	Residue	t/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a
Ferrous and Non-Ferrous Metal Production							**Air**	**Water**	**Land**	**Product**	**Residue**
Aluminum production						234	**0.023**	**0**	**0**	**0**	**0.047**
Processing scrap Al, minimal treatment of inputs, simple dust removal	100	ND	NA	NA	200	234	**0.023**				**0.047**
Ferrous and Non-Ferrous Metal Production							**0.023**	**0.000**	**0.000**	**0.000**	**0.047**

The emission to air has decreased from 0.019 µgTEQ/t to 0.023 µgTEQ/t and that to residue from 0.038µg TEQ/t to 0.047 µgTEQ/t.

Source Group 3 - Power Generation and Heating

The emissions from these power generations are calculated under Category 5 (Transport), since the emission factors are comparable to those of combustion engines in vehicles.

Heavy fuel oil is not used currently for power generation in Liberia.

The majority of people used firewood or charcoal for domestic cooking. The estimated consumption of wood used directly for cooking or converted to charcoal was 2 million tons per year (2004 estimate). Assuming an average heating value of 15 MJ/kg, the total heat production would amount to 30,000 TJ/year.

Table 28 Heat and Power Generation

Source categories	Potential Release Route (µg TEQ/TJ)					**Production**	**Annual release**				
	Air	Water	Land	Product	Residue	**TJ/a**	**g TEQ/a**	**g TEQ/a**	**g TEQ/a**	**g TEQ/a**	**g TEQ/a**
Heat and Power Generation							**Air**	**Water**	**Land**	**Product**	**Residue**
Household heating and cooking - Biomass					µg TEQ/t Ash	36,930	**3.693**	**0**	**0**	**0**	**0.261**
Virgin wood/biomass fired stoves	100	ND	ND	NA	10	25,962	**2.596**				**0.260**
Charcoal fired stoves	100	ND	ND	NA	0.1	10,968	**1.097**				**0.001**
Heat and Power Generation							3.693	0	0	0	0.261

Source Group 4: Mineral Production

Cement Production

Portland cement (or simply cement) is the single most commonly used building material in the world today. Worldwide production is at present in excess of 2.2 billion metric tons per year. The origins of cement date back to well over 5000 years ago when the Egyptians developed mortars composed of lime (CaO) and gypsum ($CaSO_4.2H_2O$) to hold together the enormous stone blocks of the pyramids. Three thousand years later, between 300 BC and 476 AD, the Romans developed the first durable concrete, with a cementitious matrix of lime and volcanic ash (chiefly SiO_2) from Mount Vesuvius, and used it to build the Coliseum and the huge Basilica of Constantine.

The use of natural cement consisting mixtures of lime (calcium oxide) and clay (aluminum silicates) emerged in England in the late 18th century. Joseph Aspdin, who obtained the first patent on cement manufacture in 1824, carefully proportioned amounts of lime and clay, then pulverized the mixture and burned it in a furnace. He named his mixture Portland cement, because the color of the powder resembled the color of the rock quarries on the Isle of Portland. Technological developments such as the rotary kiln enhanced production capabilities and allowed cement to become one of the most widely used construction materials.

Cement production may be classified by application into two primary groups: construction and energy services. The construction applications for cementing consume the lion's share of cement manufactured world-wide, but the cement produced for energy services applications is an integral part of meeting the world's energy needs and requires tighter quality control standards to meet that industry's higher demands on control of the rheological properties of the fluid slurry state, the solid state, and especially the transition from the former state to the latter, or the setting process. Additionally, cement may also become central to efforts in nuclear waste management by locking radioactive material within the cementitious matrix, where rates of diffusion of waste out of the cement serve as the dominant concern. Portland cement was first used in the energy services industry in 1903 to isolate the oil-containing region of the earth from down-hole water, a process referred to as zonal isolation.
There are four chief minerals present in a Portland cement grain: tricalcium silicate (Ca_3SiO_5), dicalcium silicate (Ca_2SiO_4), tricalcium aluminate ($Ca_3Al_2O_5$) and calcium aluminoferrite ($Ca_4Al_nFe_{2-n}O_7$). The formula of each of these minerals can be broken down into the basic calcium, silicon, aluminum and iron oxides. Cement chemists use abbreviated nomenclature based on oxides of various elements to indicate chemical formulae of relevant species, i.e., C = CaO, S = SiO_2, A = Al_2O_3, F = Fe_2O_3. The composition of cement is varied depending on the application. Hence, traditional cement nomenclature abbreviates each oxide as shown in Table 16 below.

Table 29 Chemical formulae and cement nomenclature for major constituents of Portland cement. Abbreviation notation: C = CaO, S = SiO_2, A = Al_2O_3, F = Fe_2O_3.

Mineral	Chemical formula	Oxide composition	Abbreviation

Tricalcium silicate (alite)	Ca_3SiO_5	$3CaO.SiO_2$	C3S
Dicalcium silicate (belite)	Ca_2SiO_4	$2CaO.SiO_2$	C2S
Tricalcium aluminate	Ca_3Al2O_4	$3CaO.Al_2O_3$	C3A
Tetracalcium aluminoferrite	$Ca_4Al_nFe_{2-n}O_7$	$4CaO.Al_nFe_{2-n}O3$	C4AF

A typical example of cement contains 50_70% C3S, 15_30% C2S, 5_10% C3A, 5_15% C4AF, and 3_8% other additives or minerals (such as oxides of calcium and magnesium). It is the hydration of the calcium silicate, aluminate, and aluminoferrite minerals that causes the hardening, or setting, of cement. The ratio of C3S to C2S helps to determine how fast the cement will set, with faster setting occurring with higher C3S contents. Lower C3A content promotes resistance to sulfates. Higher amounts of ferrite lead to slower hydration. The ferrite phase causes the brownish gray color in cements, so that "white cements" (i.e., those that are low in C4AF) are often used for aesthetic purposes. The calcium aluminoferrite (C4AF) forms a continuous phase around the other mineral crystallites, as the iron containing species act as a fluxing agent in the rotary kiln during cement production and are the last to solidify around the others.

Portland cement is manufactured by heating calcium carbonate and clay or shale in a kiln. During this process the calcium carbonate is converted to calcium oxide (also known as lime) and the clay minerals decompose to yield dicalcium silicate (Ca_2SiO_4, C2S) and other inorganic oxides such as aluminate and ferrite. Further heating melts the aluminate and ferrite phases. The lime reacts with dicalcium silicate to form tricalcium silicate (Ca_3SiO_5, C3S). As the mixture is cooled, tricalcium aluminate ($Ca_3Al_2O_6$, C3A) and tetracalcium aluminoferrite ($Ca_4AlnFe_{2-n}O_7$, C4AF) crystallize from the melt and tricalcium silicate and the remaining dicalcium silicate undergo phase transitions. These four minerals (C3S, C2S, C3A, and C4AF) comprise the bulk of most cement mixtures. Initially Portland cement production was carried out in a furnace, however, technological developments such as the rotary kiln have enhanced production capabilities and allowed cement to become one of the most widely used construction materials.

Cement plants generally produce various grades of cement by two processes, referred to as either the wet or dry process. The dry process uses a pneumatic kiln system which uses superheated air to convert raw materials to cement, whereas the wet process slurries the raw materials in water in preparation for conversion to cement. Cement manufacturers generally favor the dry process due to its higher energy efficiency, but the wet process tends to produce cement with properties more palatable to the energy services industry. The American Petroleum Institute (API) Class H cement used in energy service applications is produced by the wet process.[15]

[15] This content is available online at <http://cnx.org/content/m16445/1.9/>.

The only cement plant in Liberia, Cemenco, imported and still imports its inputs already processed for mixing.

Lime Production

There is no lime (calcium oxide or CaO) production in Liberia; hence, no projection is available.

Brick Production

There was no brick production during the baseline inventory; hence, no projection is available.

Glass Production

There was no glass production during the baseline inventory; hence, no projection is available.

Ceramics Production

There was none during the baseline; hence, no projection is available.

Asphalt Mixing

In 2005, 800m^3 of asphalt was reportedly imported into the country; the conversion ratio was 2.5 tons of asphalt to 1 m^3. For a number of factors, no figure is available for 2013; however, a projection was made utilizing 800m^3.

Table 30 Production of Mineral Products

Source categories	Potential Release Route (µg TEQ/t)					Production	Annual release				
	Air	Water	Land	Product	Residue	t/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a
Production of Mineral Products							**Air**	**Water**	**Land**	**Product**	**Residue**
Asphalt mixing						**2,462**	**0.000172**	**0.000000**	**0.000000**	**0.000000**	**0.000000**
Mixing plant with no gas cleaning	0.07	NA	NA	ND	ND	2,462	**0.000172**				
Production of Mineral Products							**0.000172**	**0**	**0**	**0**	**0.000**

No change in emission factor in the 2013 Toolkit regarding the source category of asphalt mixing. The asphalt mixture is made on location with no air pollution control (APC) and at the temperature of 140°C.

Source Group 5: Transport

From 2004 import data it was estimated that 120,000 tons of leaded fuels and 1,400 tons of unleaded fuel were used in 4-stroke engines. About 2,400 tons of leaded fuel was used in 2-stroke engines. According to the data from National Fire Service, in 2004, about 360,500 tons of diesel fuel was imported for transport of all kinds, fishing vessels and power generation. No heavy fuel oil was used. The results of the calculations based on the preceding figures are given in Table 31 below.

Table 31 Transport

Source categories	Potential Release Route (µg TEQ/t)					Consumption	Annual release				
	Air	Water	Land	Product	Residue	t/a *	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a
Transport							**Air**	**Water**	**Land**	**Product**	**Residue**
4-Stroke engines						**149,443**	**0.325**	**0.000**	**0.000**	**0.000**	**0.000**
Leaded fuel	2.2	NA	NA	NA	NA	147,720	**0.325**				
Unleaded gasoline without catalyst	0.1	NA	NA	NA	NA	1,723	**0.000**				
2-Stroke engines						**2,954**	**0.010**		**0**	**0**	**0**
Leaded fuel	3.5	NA	NA	NA	NA	2,954	**0.010**				
Diesel engines						**443,775**	**0.044**	**0.000**	**0.000**	**0.000**	**0.000**
Regular Diesel	0.1	NA	NA	NA	ND	443,775	**0.044**				
Transport							0.380	0	0	0	0

No change in emission factors in the 2013 Toolkit regarding the relevant transport source categories.

Source Group 6: Uncontrolled Combustion Processes

Waste Burning and Accidental Fires

Bush and forest fires were not frequent in Liberia according to the Ministry of Agriculture (MOA). However, agricultural waste burning was and is still common. On the basis of an expert judgment, a conservative estimate of 1 million tons of biomass burnt was used for this calculation.

Since no municipal waste incinerators exist in Liberia, household waste is burnt either domestically or elsewhere. For this calculation it has been assumed that 100 kg of solid waste per person per year are burnt in open air (2/3 at homes and 1/3 elsewhere).

Accidental Fire in Houses and Vehicles

In the absence of national fire data, assumed 150 fires per year in houses and 200 vehicle fires per year occurred, using the experience of similar countries in the region.[16]

Table 32 Uncontrolled Combustion Processes

Source categories	Potential Release Route (µg TEQ/t)					Production	Annual release				
	Air	Water	Land	Product	Residue	t/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a
Open Burning Processes							Air	Water	Land	Product	Residue
Biomass burning						923,249	**0.462**	**0**	**0.046**	**0**	**0**
Agricultural residue burning in the field of cereal and other crops stubble, not impacted	0.5	ND	0.05	NA	NA	923,249	**0.462**		**0.046**		
Waste burning and accidental fires						370,715	**46.975**	**0**	**1.573**	**0**	**0**
Fires at waste dumps (compacted, wet, high Corg content)	300	ND	10	NA	NA	123,100	**36.930**		**1.231**		
Accidental fires in houses, factories	400	ND	400	NA	NA	185	**0.074**		**0.074**		
Open burning of domestic waste	40	ND	1	NA	NA	246,200	**9.848**		**0.246**		

[16] Assume approximately a ton of materials is consumed in each house fire event and 5 tons in each vehicle fire event.

Accidental fires in vehicles (per vehicle)	100	ND	18	NA	NA	1,231	0.123		0.022		
Open Burning Processes							47.437	0	1.619	0	0.000

Source Group 7: Production and Use of Chemicals and Consumer Goods

Activities in this source group are either irrelevant or produce very negligible footprint in respect of UPOPs releases.

Source Group 8: Miscellaneous

There are no crematoria in Liberia. Bodies of dead Ebola patients are being cremated in Marshall but it is difficult to collect the required information for purposes of updating. Only a few dry cleaners are inn operation in the capital. Drying of biomass and smoking of fish are not practiced to any significant extent. Therefore the only activity to be considered in this category is tobacco smoking. Due to lack of actual record on smoking in the country, it was assumed that 500,000 persons smoked a pack of cigarette each a day and a pack weighs on average approximately one ounce (28.375 grams)[17].

Table 33 Miscellaneous

Source categories	Potential Release Route (µg TEQ/t)					**Production**	**Annual release**				
	Air	Water	Land	Product	Residue	**t/a**	**g TEQ/a**	**g TEQ/a**	**g TEQ/a**	**g TEQ/a**	**g TEQ/a**
Miscellaneous							**Air**	**Water**	**Land**	**Product**	**Residue**
Tobacco smoking						**6,374**	**0.0006**	**0**	**0**	**0.000**	**0.00064**
Cigarette (per million items)	0.1	NA	NA	NA	0.1	6,374	**0.0006**				**0.001**
Miscellaneous							**0.0006**	**0**	**0**	**0.000**	**0.001**

Source Group 9: Disposal/Landfill.

Based on data from other countries in the region, the daily per capita generation of domestic wastewater was estimated at 100 liters (0.1ton/day). In urban areas this quantity is likely to be

[17] The weight of a package of cigarettes depends on a few different things. It will depend on the brand and if they are shorts or longs. Most packages weigh about one ounce (or $28.375x10^{-6}$t). Furthermore, the amount a carton of cigarettes weighs can vary, depending on brand, type and size of the cigarettes. Cigarettes come in varieties, like slims, wides and regulars. On average, a carton of cigarettes will weigh around 250 grams ($250x10^{-6}$t).

higher and in some places in the country it might be lower. Since Liberia does not have any wastewater treatment plants, 100% open dumping is assumed.[18]

Table 34: Disposal and Landfill

Source categories	Potential Release Route (µg TEQ/t)					Production	Annual release				
	Air	Water	Land	Product	Residue		g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a
Disposal							**Air**	**Water**	**Land**	**Product**	**Residue**
Open water dumping						**134,794,303**	**0.000**	**0.674**	**0.000**	**0.000**	**0.000**
Mixed domestic and industrial wastewater	NA	0.005	NA	NA	NA	134,794,303	**0**	**0.674**			
Disposal/Landfill							**0.000**	**0.674**	**0**	**0.000**	**0**

Source Group 10: Hot Spots

No hotspot was found. Moreover, hotspots for which emission factors are available in Toolkit 2013 do not exist in Liberia. Below is the summary of the updated inventory.

Group	Source Groups	Annual Releases (g TEQ/a)				
		Air	Water	Land	Product	Residue
1	Waste Incineration	0.739	0.000	0.000	0.000	0.004
2	Ferrous and Non-Ferrous Metal Production	0.023	0.000	0.000	0.000	0.047
3	Heat and Power Generation	3.693	0.000	0.000	0.000	0.261
4	Production of Mineral Products	0.000	0.000	0.000	0.000	0.000
5	Transportation	0.380	0.000	0.000	0.000	0.000
6	Open Burning Processes	47.437	0.000	1.619	0.000	0.000
7	Production of Chemicals and Consumer Goods	0.000	0.000	0.000	0.000	0.000
8	Miscellaneous	0.001	0.000	0.000	0.000	0.001
9	Disposal	0.000	0.674	0.000	0.000	0.000
10	Identification of Potential Hot-Spots				0.000	0.000

[18] For 3 million people (2004 population estimate), the annual quantity of wastewater produced would be 0.1 tons x 365 x 3,000,000.

1-10	**Total**	**52.272**	**0.674**	**1.619**	**0.000**	**0.312**
	Grand Total			**55**		

Open burning of domestic and agricultural waste is by far the single most important source of UPOPs releases to air and land, while untreated domestic waste water is the only known significant source of UPOPs releases to water.

10.5 Action Plan – ECOWAS BAT/BEP Forum

The workshop on the establishment of the BAT/BEP Forum for the ECOWAS and G5 countries was held from 8 to 9 December 2011 in Lomé, Togo. Member States of the Economic Community of West African States (ECOWAS) and the non-member States of this organization (Central African Republic, Mauritania, Democratic Republic of Congo, Chad and Sao Tome & Principe) that are Parties to the Stockholm Convention on POPs, decided to create a Forum on BAT/BEP within the framework of a geographical set named: Sub-region of ECOWAS and the Group of 5 (abbreviated ECOWAS + G5) to meet their obligations under Article 5 of the Convention. ***The forum is called: Forum on BAT/BEP for the sub-region of ECOWAS and the group of 5 (ECOWAS + G5 BAT/BEP Forum)***. The BAT/BEP Forum is one of the organizational tools capable of enabling participating countries such as Liberia to implement the Marrakech Process on sustainable production and consumption adopted in 2002 by the Johannesburg Summit.

Objectives of the Forum

1. The BAT/BEP Forum is a voluntary (not mandatory) regional platform for collaboration and cooperation on BAT/BEP. It is open to all countries in the sub-region of ECOWAS + G5. The main objectives of the BAT/BEP Forum are to:

   Serve as platform for dissemination of information and exchange of experiences among participating countries on various aspects of the implementation of BAT/BEP;

   Provide a regular report on the impacts of BAT/BEP in the industrial sectors and other relevant sectors covered by the Convention;

   Help build the capacity of member countries to facilitate the transfer of green technologies, including or taking into account the increased use of local and traditional knowledge and techniques in the industrial context of the region.

2. **Task of the Forum:** The Forum's main task is to perform timely works for the implementation, promotion and dissemination of BAT/BEP in the sub-region in accordance with the guidelines of the Stockholm Convention (SC) in order provide assistance for the implementation of the action plans with a focus on the chemicals PCDD/PCDF, PCB, HCB, the industrial production processes and other sources of releases of these substances as listed in Annex C of the Convention.[19]

3. The state of scientific knowledge in the assessment of releases as well as in the environmental levels of the chemicals listed in Annex C and what is considered as

[19] *Unintentionally produced POPs (UPOPs) are listed in Part I of Annex C while their sources are mentioned in Part II and Part III of the same annex.*

BAT/BEP will change over time. The guide on BAT/BEP will be constantly updated to follow these changes. Depending on the process that is the source of release of chemicals listed in Annex C, the economic and social conditions in a country are a factor for determining the BAT/BEP to be implemented.

4. For new sources of these chemicals within the categories of sources that justify the use of best techniques, as identified in their national action plans, Parties will have to focus initially on categories of sources identified in the Part II of Annex C. Addressing existing sources is an opportunity for a Party to reduce releases while modernizing the local industrial sector. Considering the priority existing sources identified in its national action plan, a party will need to consider measures to encourage the necessary changes in the processes or in the management practices that could lead to a success of BAT/BEP. Such changes could be introduced in stages over a period and could be part of the modernization plans of a facility.

5. In addition to making the existing guidelines on BAT/BEP more understandable and easier to use, the Forum of the sub-region of ECOWAS + G5 will develop, if necessary, a guide taking into account what are currently the best environmental practices for the various source categories of each country.

At the end of the workshop on the establishment of the BAT/BEP Forum, the five (5) sectors listed below were selected as priority sectors for the introduction of BAT/BEP:

Priority 1- Uncontrolled combustion processes (open burning of municipal solid waste, pre-/post -harvest burning of agricultural residue, forest and bush fires, etc.)

This is an important priority for Liberia on the basis of the conclusion derived from the results of its previous and current revised UPOPs inventories.

Priority 2- Waste incineration (especially biomedical waste)

Priority 3-Power generation and heating (thermal power generation with fossil fuel or biomass fuel)

Priority 4- Transport (the use of leaded fuel has been phased out in the ECOWAS sub region since 2005; remaining issues to deal with include, among others, regulation of the importation of second-hand vehicles, etc.)

Priority 5- Mineral production (the issues of concern will include, among others, the use of impacted or virgin biomass fuels and hazardous waste as co-fuels)

11 SOCIO-ECONOMIC ANALYSIS ON POPS IN LIBERIA

This analysis is aimed at identifying POPs in Liberia, their sources in environments and how they affect communities and community dwellers as well as the economy.

There are nine POPs listed that are destined for elimination with specific, time-limited exemptions. These include the agricultural chemicals aldrin, chlordane, dieldrin, endrin, heptachlor, mirex, and toxaphene, as well as the industrial chemicals hexachlorobenzene (HCB), and polychlorinated biphenyls (PCBs).[20] There are other POPs that are subject to restrictions on production and use, but eligible for specific exemptions for acceptable purposes and this just one substance, the pesticide DDT. Interestingly there are POPs that are unintentionally produced, for example as industrial by-product and combustion processes these include; polychlorinated dioxins and polychlorinated furans.[21]

The nine POPs destined for elimination and the one subject for restriction main sources in Liberia has not been established due to lack of sufficient evidence document. However, studies have proven that POPs enter Africa by means of export. According to Weir and Schapiro, 12 POPs have now been banned or restricted in most industrialized countries, these chemicals continue to be produced and exported to Third World countries where regulations are laxed.[22] For instance in Liberia, customs officials have not received sufficient trainings to enforce the international guideline on POPs. In fact, since the National Implementation Plan for the Stockholm Convention on Persistent Organic Pollutants (POPs) was developed in Liberia by the Environmental Protection Agency (EPA) of Liberia in August 2006, there has been no proper control mechanism regarding chemicals entering into the country. Electronic materials containing POPs do not go through screening at the Liberian custom due to low capacity to detect these electronic appliances that are dangerous to health.

This analysis is particularly focused on the unintentionally produced POPs as well as their socio-economic impact to communities and the Liberian economy. The issue of pollution is evident in Liberia thereby causing serious environmental health problems. Thus, the need to find solution to the problems is very significant. Smith (2001) stated that, directly through exposure to xenobiotics and indirectly through systemic environmental events, many health problems are inextricably connected to environmental factors.[23]

Dioxins and Furans

Dioxins and Furans are unintentionally produced during most forms of combustion, including burning of municipal and medical wastes, backyard burning of trash, and industrial processes. Also can be found as trace contaminants in certain herbicides, wood preservatives, and in PCB Mixture [24]

These unintentionally produced pollutions continue to persist in environment for a longer period of time thereby posting serious health and environmental problems which have negative impact on human and animals.

MAIN SOURCES OF DIOXINS AND FURANS IN LIBERIA:

In Liberia, Dioxins and Furans are released in communities during the burning of backyard garbage, burning of community waste, vehicular emissions, and medical waste and during

20 Stockholm convention (2001)
21 Stockholm convention (2001)
22 Francis O. Adeola, Department of Sociology University of New Orleans New Orleans, LA 70148; Weir and Schapiro 1991
23 Smith, K.R. 2001. Environment and health: Issues for the new U.S. administration. Environment 43, 4, 35-40
24 The POP Treaty (2001)

industrial processes. Most communities in and out of Monrovia prefer to burn backyard trash with the notion that the method is the best to keep their communities clean.

As part of the National Implementation Plan of 2006, there should be programs in place to monitor garbage disposal in communities. Secondly, the 2006 Implementation Plan seeks to establish suitable storage and garbage disposal site so as to avoid waste in communities. In spite of all of the good plans, programs have not been put in place and suitable storage and garbage disposal site have not been identified leaving community dwellers with no other alternative but to burn garbage. The act of burning garbage rather than deposing it to a particular locality to be properly disposed by city cooperation is not only affecting the very community producing the pollution but rather other communities as well, and communities in Liberia especially in cities are cluster. Communities are even more affected when winds blow during the burning of garbage. Water as well as food gets contaminated causing more health hazard to people drinking the water and eating these foods.

Figure 13. Both community members and passerby are affected by this kind of pollution in Liberia. Most of them are aware that burning trash is dangerous to their health while others are not aware at all and feel that they are cleaning their environment of dirt.

Figure 14. It is even worse in communities that have big markets. In this area of red-light (poultry community market), garbage is not only dumped by community dwellers but also traders. Marketers and community dwellers dump wastes at this site in the community. If the garbage dumped is not collected by the City Corporation, it turns to huge hip, where some unknown persons sets the garbage on fire of which Community members suffer the effect of garbage hip that is often set on fire.

It is important to note that contaminated sites are causing mass suffering and continues widespread of human and environmental health hazards in developing countries of which Liberia is no exception. Most of the community dwellers contacted are aware that inhaling excessive smoke from incomplete combustion possess health danger while others are not aware at all. According to Yassi et al, Exposure to chemical hazards may occur via all types of exposure: inhalation, oral ingestion, absorption through the skin, absorption through the eyes.[25]

[25] Yassi et al. 2001

Figure15. The most hazardous part is that, pollutions produced do not remain in these environments but the negative spillover effect is that the Smoke from the pollution spreads to other communities especially when the wind blows. It is difficult to get rid of such fire at some point in time because the fire tends to penetrate the root of the waste and

Regarding medical waste disposal, it depends on the type of waste. Some are dumped in pits while others go through the process of incineration. This process of incineration is also harmful to communities.

Figure 16. The two main kinds of hospital wastes organic and solid are disposed in different ways. For example, organic waste such as: placentas, blood product among others are placed in deep pits, while the solid waste such as: syringes, gloves, bandages, cotton are incinerated at different pressure according to their kinds. Syringes with needles are placed in sharp object box that when burned, caked together. Other medical waste such as: vials and ampoules are crushed and go down into a pit. These methods of waste deposit are good however they are done within the community and cause health hazard most especially when the incineration process is taking place.

Importantly, domestic wastes such as food are collected from hospitals to be properly disposed. But medical wastes remain in the hospital for their disposal. What was a high concern was that the medical waste was disposed in the hospital's compound which is part of the community. During the process of incineration, the smoke from the incineration spreads into the community thus creating pollution.

Due to this high voltage incinerators were brought in to take care of the Ebola virus. Also 12 state of the art incinerators were imported into the country by UNICEF for medical waste incineration.

11.1 SOCIO-ECONOMIC IMPACT

Even though it may be difficulties in determining the socio-economic impact of POPs on environment and health in Liberia since there is no base line study to provide evidence. However, based on analysis conducted in few communities, socio-economic impact of POPs in Liberia can be viewed in two ways:

Positive Socio-economic impact:

If the Government of Liberia is willing to undertake cost effective measures to reduce the spreads of POPs, this will not only benefit the individual but also the economy. Developing mitigation strategies to curtail the spreads of POPs means that sufficient efforts have to be applied to restrict the burning of mass garbage, medical waste, as well as back yard trash. The restriction of POPs in environments will lead to:

- Reduction of expected adverse effect to health, due to inhalation of pollution.
- Healthy environment as long as they breathe clean air.
- Healthy workforce is produced
- Increase in income
- Immense contribution is made to the economy due to the participation of healthy workforce and economic growth.

Negative Socio-economic impact:

Avoiding sustainable measures to restrict the spread of POPs due to the direct exposure of factories workers and indirect exposure through inhalation, contaminated food and water, will lead to the following:

- Endangering public health as well as individuals,
- Limited ability to contribute to the workforce and generate income due to poor and deplorable health condition,
- Reduction in family's income
- Gaps/reduction in the Nation's workforce,
- And hence, reduction in economic growth.

12 GENDER DIFFERENCES IN SOCIO-ECONOMIC IMPACT OF POPS

Socio-economic impacts of Persistent Organic Pollutants (POPs) affect girl/women and boy/men. However, these pollutions affect both sexes differently. According to PRB 2001, deforestation, water scarcity, soil degradation, and exposure to agricultural and industrial chemicals and organic pollutants affect women and men in varying ways.[26]

Liberia is also a member of The Beijing Platform of which chapter 4 recommends strengthening women's participation and leadership as part of a holistic, multidisciplinary, and intersectoral approach to sound environmental management.[27]

The Gender Policy of Liberia generally highlights gender mainstreaming. The Ministry of Gender and Development also developed strategic interventions for Government Ministries, Agencies and Commission to easily mainstream activities in their work plans. However, there is no proper monitoring to ensure implementation of these strategic interventions.

Gender is commonly described as the socially constructed roles, behavior, activities and attributes that a particular society considers appropriate for men and women. These distinct roles and behavior may give rise to gender inequalities. Some of these differences between

[26] Population Reference Bureau (PRB 2001)

27 Beijing Declaration and Platform for Action, Fourth world conference on Women (1995)

men and women can lead to inequities between men and women in both health status and access to health care. [28]

Since gender is described as the socially constructed roles, in Liberia as well as other African countries, the roles ascribed to females by society are different as compared to their male counterparts. In a culturally constructed community in Liberia, most of the roles that females perform keep them in their respective communities for example cooking, fetching fire wood, fetching water, housekeeping, babysitting, among others. Even if they are involved in petit trade, they often conduct their trade activities in their communities. Women and children are most often in the communities hence, if a community is affected by pollution, they suffer the most. Secondly, the gender roles they perform often keep them in their respective communities. For instance in the poultry market community as well as other communities, women and children suffer most from the combustion that occurred. Since these women and children stay home to do household work including petit trade, they are highly affected and fall sick from flu and severe headache.

Studies have proven that higher exposure to Indoor Pollutants Soot from burning biomass fuels such as wood, charcoal, or agricultural residues for cooking and heating primarily affects women and children because they spend more time indoors than men. Epidemiological studies in developing countries have linked exposure to indoor air pollution from traditional fuels with acute respiratory infections in children.[29] The study also revealed that exposure to high levels of indoor smoke is also associated with pregnancy-related problems such as stillbirths and low birth weight infants.

Men also suffer the effect of pollution base on their specified roles. In Liberia, most men are found in the industrial setting where high levels of pollutions take place during manufacturing. An example is the Cemenco factory where cement is produced. The factory is mainly male dominant. During production, factory workers are not sufficiently protected from the pollution. As a result most of them are affected by skin disease especially those who have worked in the production area for more than 8 years. Some also suffer from eyes and ears problems. This negative feedback during production cannot be under estimated as the study conducted by Yassi et al, stated that exposure to chemical hazards may occur via all types of exposure and these include inhalation as well as absorption through the skin and the eyes.[30] There are also reproductive problems associated with males' exposure to pollution. According to Francis O. Adeola 2004, contact with pollution especially endocrine disruptions decreased sperm count in men.[31] In addition, exposure to pesticides has been linked to testicular cancers and lower sperm counts[32]

12.1 THE IMPORTANCE OF GENDER MAINSTREAMING IN THE NATIONAL IMPLEMENTATION PLAN IN LIBERIA

Gender mainstreaming is "the process of assessing the implications for women and men of any planned action, including legislation, policies or programs, in all areas and at all levels. It is a strategy for making women's as well as men's concerns and experiences an integral dimension of the design, implementation, monitoring and evaluation of policies and programs in all political, economic and societal spheres so that women and men benefit

[28] http://www.ask.com (assessed April 21, 2014)

[29] Population Reference Bureau (PRB 2001)

30 Yassi et al. 2001

31 Francis O. Adeola, Department of Sociology, University of New Orleans, New Orleans, LA 70148 Human Ecology Review, Vol. 11, No. 1, 2004 27

[32] Alejandro Oliva, Alfred Spira, and Luc Multigner, "Contribution of Environmental Factors to the Risk of Male Infertility," Human Reproduction 16 (2001): 1768-76. Population Reference Bureau (PRB 2001)

equally and inequality is not perpetuated. The ultimate goal of mainstreaming is to achieve gender equality". [33]

During the development of the 2006 National Implementation Plan, the issues of gender were ignored. A successful National Implementation Plan will require gender mainstreaming in all aspect (planning, implementation, monitoring and evaluation) given that both sexes performed different roles and are affected differently by pollution. In order to ensure that the National Implementation Plan is engendered, there is a need for sex disaggregated data so as to have a baseline data to track gender progress in all activities and this can only be done through gender analysis.

Gender Analysis refers to the variety of methods used to understand the relationships between men and women, their access to resources, their activities, and the constraints they face relative to each other. Gender analysis provides information that recognizes that gender, and its relationship with race, ethnicity, culture, class, age, disability, and/or other status, is important in understanding the different patterns of involvement, behavior and activities that women and men have in economic, social and legal structures.[34]

Gender analysis will inform the National Implementation Plan (NIP) on strategic intervention to mainstreaming gender in all aspects of the National Implementation Plan and thus ensure gender equality. As a matter of fact, males and females in various economic settings are affected by pollution differently including their social lives. A proper gender analysis will better inform the NIP on appropriate strategic that will benefit both sexes. The idea of treating sex differently during implementation cannot be overlooked when in fact article 10 C of the Stockholm convention on POPs states the importance of, "Development and implementation, especially for women, children and the least educated, of educational and public awareness programs on persistent organic pollutants, as well as on their health and environmental effects and on their alternatives".

In the Poultry market community for example, women are found in the community doing household as well as petit trade, if they fall sick due to pollution, they are oblige to forgo their duties and at the same time spend funds in order to get well. This is causing them economic loss. Moreover, if the child/children get sick, the women are compelled to abandon their activities to cater to the sick child/children causing them loss as well. As one mother said, *"I cannot do anything to escape the smoke because this is the place I get my living"*.

Men are found in the factory where pollutions take place during production processes. However, with a gender sensitive Implementation Plan, strategic interventions can be directed towards both sexes differently.

The Gender Analysis should be conducted in different socio-economic settings as well as their socio-economic circumstances, to help determine appropriate and sustainable interventions. The analysis will be able to identify gaps before and during the implementation and hence suggest to management for appropriate measures and improvement. This aspect can also be captured during monitoring and evaluation.

To mainstream gender in the National Implementation Plan, gender analysis will constitute sex disaggregated data. The analysis will be conducted at three levels in the areas targeted for implementation.

1. Micro Level: Gender analysis at the Micro level will include identifying interventions that will benefit both males and females differently since they are affected differently

[33] United Nations Economic and Social Council (ECOSOC) (July 1997)
[34] http://www.acdi-cida.gc.ca

by pollutions. This will also include identifying gender sensitive employees, partners as well as stakeholders during the planning stage.

2. Meso Level: Gender analysis at the meso level is vital. This will include the collection of sex disaggregated data and analyzing the data to reveal the level of inequality that exist in the areas targeted for implementation. Results from the analysis will be used to support/strengthen interventions.

3. Macro Level: Gender analysis at the macro is very important. If our National Policy frameworks are not engendered, our implementation may not yield fruitful results because there are not regulations to support the implementation process hence, gender analysis at the macro level will entail analyzing the country's related policy to determine policy coherence in gender mainstreaming.

13 PROPOSED MEASURES

Finding mitigation strategies to curtail pollutions in Liberia means, the National Implementation Plan should consider the following activities to address the issues.

Table12. 5 Years Action Plan To Manage POPs In Liberia

Objective: To develop comprehensive legislation to support an integrated approach to POPs/chemicals management and to mainstream gender in POP National Implementation Plan			
Activity	Issues to Address	Expected outcome	Implemented by
Develop a National Program for the management of Medical waste	• The lack of programs for the management of medical waste adds to the problem of dioxin and furans emissions. • A core network of experts to conduct risk assessment should be established. • Medical waste plan and policy should be developed. • Reduce low-tech incineration of medical waste	• Medical waste plan and policy finalized and developed. • Medical waste low-tech incineration is reduced. • Lower emissions of Dioxins and Furans from medical facilities. • National medical waste management program improved	EPA, MOH, UNICEF, Law
Develop a plan for reduction of open garbage burning with provision for alternatives	• Open combustion of domestic and agricultural waste is by far the most important source of	• Amount of garbage collected is recorded.	EPA, MCC, MLME, CEEP

in areas without garbage collection.	UPOPs emissions to air in Liberia. Garbage collection is not available in many areas. • Liberia does not have municipal garbage incinerators or safe landfill sites.	• Proper planning document is produced. • Plan is implemented. • Alternatives are produced.	
Ensure implementation of relevant international Agreements and other protocols	• National legislation for the implementation of relevant Agreements on POPs and other chemicals missing. •	• Legislation for the implementatio n of the Stockholm and Rotterdam Conventions and other protocols enacted.	National Focal Convention Secretariat, Min. of Foreign Affairs, EPA NCCTF
Adopt the GHS	• National legislation not compliant with GHS requirements	• GHS anchored in Liberian law	MOH, EPA and NPHIL
Develop regulations for export, import, transport and storage of hazardous chemicals management including pesticide and PCBs	• Policy document and regulations for hazardous chemicals management lacking	• Regulations for hazardous chemicals management produced	EPA, MOH, NCCTF
Development of National Policy program for the sound management of POPs	• National Policy not defined • No guidelines and regulatory framework existing.	• National policy on POPs produced • Compliance strengthened	EPA, law firms Advocated, MPEA, M
Produce a Clear Air Act for Liberia.	• Liberia does not have a Clear Air Act. • Lack of standards for the quality	• National Ambient Air Quality Standard for Liberia established. • Air emission standard	EPA, MOH
Create gender baseline	• No Data in Liberia to prove which sex	• Appropriate	LISGIS, EPA

data	is mostly affected by POPs	intervention	
Train staff on the importance of Gender issues to environment	• Staffs are not fully informed on the effect of pollution to gender differences.	• Management informed on appropriate strategies.	EPA,
Integrate gender perspective in planning, monitoring and evaluation processes.	• No document to prove gender mainstreaming.	• NIP to be engendered	EPA
Ensure that both males and females have access to participate in decision concerning environment.	• No evidence to prove that both male and female equally participates in decision about environment pollution.	• Male and female full participation in decision making about environment.	EPA
Conduct workshop on Socio Economic Impact of POPs on human and the environment	• Health effects of chemical pollution have not been researched. • Economic impacts are not known	• Social economic Impacts of POPs known	EPA, MOC, MOH, UL

14 CONCLUSION

While it is true that Liberia is not chemicals producing country, the fact remains that persistent organic pollutants (POPs) are chemicals that characterized by their ability to travel through long distances. This means that these chemicals can be found in places where they were never produced. Hence, the existence of both old and new industrial in Liberia is not a debate but a reality.

Moreover, POP chemicals are imported into Liberia either in their chemical form or as products containing these chemicals. What is challenging, in conducting researching in areas that have to do with chemicals or chemical related issues, is the very weak institutional policies and regulations regarding chemicals in the country and lack of coordination amongst government institutions whose interplay with the handling of chemicals.

Since Liberia accession and ratification to international agreements that regulate the movement of chemicals and chemical related materials, there has been increasing awareness of the effects that chemical pose to the environment and man when they are not properly handled. However, it is highly challenging in detecting chemicals (POPs) due to the lack of logistics and trained personnel. Given the importance in manufacturing and agricultural industries, more chemical are imported in the country, even the banned chemicals are imported either under different trade name or with wrong label to deceive the consuming publics.

The information gathered here is just a baseline record for the situation regarding new POP-chemicals in Liberia. Much more information can be gathered with the proper preparation, publicity, logistical support, and personnel. With the full backing of all the stakeholder institutions, it my hope that the next phase of this research will produce results in which the old and new industrial POP chemicals present in Liberia will be quantified.

15 RECOMMENDATIONS

1. The enabling activities to review and update the National Implementation Plan for the Stockholm Convention on POPs should be a continuous process and should be conducted at three or four years interval. This will safeguard the environment and human lives given the accelerated rate at which new chemicals are produced.

2. Existent institutional policies and regulations on chemicals and chemical related materials should be strengthened and enforced

3. Intersectoral cooperation and coordination amongst institutions dealing with chemical should be promoted.

4. The Stockholm Convention should upgrade and furnish EPA laboratory with the required logistics so that the techniques needed to detect POP chemical in the environment will be learned in this lab.

Appendix A

Facts About the POPs chemicals

POPs Pesticides

Aldrin - Aldrin and dieldrin are man-made insecticides that are similar in structure. Aldrin breaks down into dieldrin in the body and in the environment. These chemicals are used to control soil insects, such as termites, corn rootworm, wireworms, rice water weevil and grasshoppers. From 1950 to 1970, aldrin and dieldrin were used on crops such as corn, cotton and potatoes. Aldrin and dieldrin are defined as hazardous solid waste. Aldrin and dieldrin bind tightly to soil and slowly evaporate into the air. Plants take in these chemicals from the soil and store them. Dieldrin is also stored in animal fat and leaves the body slowly. Dieldrin now exists everywhere in the environment, but at very low levels. Aldrin and dieldrin are both known endocrine disruptors. Human studies predict that levels above 0.20 milligrams of dieldrin in a liter of blood may result in harmful effects, such as convulsions or uncontrollable muscle movements. Residues of aldrin were detected in all samples of bird casualties, eggs, scavengers, predators, fish, frogs, invertebrates and soil. Ingesting high levels of these chemicals results in convulsions and death. Ingesting moderate levels over a longer period of time may also cause convulsions, because these chemicals build up in our bodies over time Other effects from long-term exposure include headaches, dizziness, vomiting, irritability and uncontrolled muscle movements. Aldrin and dieldrin are not used in Liberia

Chlordane - Chlordane is a broad spectrum contact insecticide that has been used on agricultural crops including vegetables, small grains, maize, other oilseeds, potatoes, sugarcane, sugar beets, fruits, nuts, cotton and jute. It has also been used extensively in the control of termites. Adheres strongly to soil particles and is not likely to enter groundwater, but can stay in soil for more than 20 years because it is slow to break down. It does not dissolve easily in water but does evaporate into the air. Builds up in the tissues of fish, birds and mammals. Chlordane is a known endocrine disruptor. Exposure by: Eating crops grown in contaminated soil, such as corn, root crops, citrus; eating fish or shellfish caught in water contaminated by chlordane; breathing air or touching soil near homes treated for termites with chlordane; breathing air or touching soil near waste sites or landfills that contain chlordane

Dieldrin- Dieldrin has been used in agriculture for the control of soil insects and several insect vectors of disease but this latter use has been banned in a number of countries due to environmental and human health concerns. Principle contemporary uses are restricted to control termites and wood borers and against textile pests. As aldrin is readily and rapidly converted to dieldrin in the environment and in organisms, the levels of dieldrin detected likely reflect the total concentrations of both compounds Dieldrin binds strongly to soil particles and hence is very resistant to leaching into groundwater. Volatilization is an important mechanism of loss from the soil and, because of its persistent nature and hydrophobicity, dieldrin is known to bioconcentrate. The half-life of dieldrin in temperate soils is approximately 5 years. This persistence, combined with high lipid solubility, provides the necessary conditions for dieldrin to bioconcentrate and biomagnify in organisms. It is likely that dieldrin is bioconcentrated by aquatic organisms rather than bioaccumulated. Dairy products, such as milk and butter, and animal meats were the primary sources of exposure.

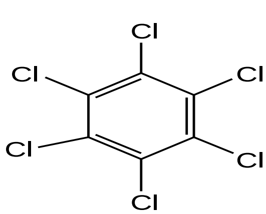
Endrin - Can contaminate surface water from soil runoff. Doesn't dissolve well in water. Clings to the bottom sediments of rivers, lakes and other bodies of water. Generally not found in the air except when applied to fields during agricultural applications. May stay in the soil for more than 10 years. Endrin is a foliar insecticide used mainly on field crops such as cotton and grains. It has also been used as a rodenticide to control mice and voles. It is rapidly metabolised by animals and does not accumulate in fat to the same extent as other compounds with similar structures. Endrin is highly toxic to fish. The chemical properties of endrin (low water solubility, high stability in the environment, and semi-volatility) favor its long range transport, and it has been detected in arctic freshwater. The main source of endrin exposure to the general population is residues in food however, contemporary intake is generally below the acceptable daily intake.

Heptachlor - Insoluble in water, Heptachlor binds to aquatic sediments and bioconcentrates in the fat of living organisms. It evaporates slowly in air. The half-life of Heptachlor in temperate soil is up to two years. An insecticide used primarily to kill soil insects and termite, it has also been used to control cotton insects, grasshoppers, and some crop pests, especially for corn. In addition, it has been used to combat malaria. Heptachlor is metabolized in animals to heptachlor epoxide, whose toxicity is similar to that of heptachlor, and which may also be stored in animal fat. WHO suggests that food is the major source of exposure of heptachlor to the general population, as well as: ingestion of residues in food, i.e., eating crops grown in soil that contains Heptachlor or eating fish, dairy products, and fatty meats from animals exposed to Heptachlor in their food, inhalation in homes treated for termite control, drinking contaminated water, or skin contact with soil near waste sites or landfills, breast milk from mothers who had high exposures. IARC has classified heptachlor as a possible human carcinogen. It has been banned in more than 50 countries and severely restricted in seven.

Hexachlorobenzene (HCB)

Molecular formula: $\mathbf{C_6Cl_6}$

Structural formula:



CAS Number: **118-74-1**

USES: Hexachlorobenzene (HCB) was first introduced in 1945 as fungicide for seed treatments, especially for control of burnt of wheat, and used to make fireworks, and ammunition. It also had industrial uses in organic synthesis as a raw material for synthetic rubber.

Commercially, HCB is produced by reacting benzene with excess chlorine in the presence of ferric chloride at 150-200 degrees Celsius.

Hexachlorobenzene is a chlorinated hydrocarbon an industrial chemical but it is also formed as a waste product in the production of several chlorinated hydrocarbons such as tetrachloroethylene, trichloroethylene, and carbon tetrachloride, and is a contaminant in some pesticides such as pentachloronitrobenzene and pentachlorophenol. Hexachlorobenzene is also released in the environment due to ongoing use in developing countries and improper storage or disposal in developed countries.

In addition, hexachlorobenzene may be produced as a byproduct in waste streams of chloralkali plants and wood preserving plants, and in fly ash and flue gas effluents from municipal incineration.

Environmental fate and toxicity

HCB is quite volatile and can be expected to partition into the atmosphere due to its volatility and it is also known to bioconcentrate in the fatty tissue of living organisms. The most notable episode involving the effects of HCB on humans involved the ingestion of HCB-treated seed grain in eastern Turkey between 1954 and 1959. The patients who ingested the treated seed experienced a range of symptoms including photosensitive skin lesions, hyper pigmentation, hirsutism, colic, severe weakness, porphyrinuria, and debilitation. Mothers who ingested HCB-treated seeds passed the HCB to their children by placental transfer and through maternal milk. Children born to these women developed "pembe yara" or pink sore, with a reported mortality rate of approximately 95%. A study of 32 individuals 20 years after the outbreak showed that porphyria can persist years after the ingestion of HCB. HCB is very persistent. This persistence, combined with a high partition coefficient (log KOW = 3.03–6.42), provides the necessary conditions for HCB to bioconcentrate in organisms.

HCB is toxic to humans and animals when long-term exposure occurs (consuming dairy products or meat from cattle grazing on contaminated pastures, eating low levels in contaminated food, eating or touching contaminated soil, or drinking small amounts in contaminated water, breathing low levels in contaminated air, For babies, drinking contaminated breast milk from exposed mothers, working in a factory that uses or produces HCB unintentionally. Unintentional production is possible since HCB is formed as a byproduct of chemical manufacture and waste incineration). Its main health effect is liver disease. HCB was determined to be a probable human carcinogen. The chemical properties of HCB favour its long-range transport, and HCB has been detected in arctic air, water and organisms. HCB is ubiquitous in the environment, and has been measured in foods of all types. HCB was one of two organochlorines detected in all samples of Spanish meat and meat products. HCB is known to cause liver disease in humans (porphyria cutanea tarda) and has been classified as a possible carcinogen to humans by the International Agency for Research on Cancer, IARC. The acute toxicity of HCB is low with LD50 values of 3.5mg/kg for rats. Mild effects of the [rat] liver have been observed at a daily dose of 0.25mg/kg-bw.

Mirex - Considered one of the most stable and persistent pesticides, with a half life of up to 10 years. Does not dissolve easily in water, but it easily sticks to soil and sediment particles. It is not likely to travel far through the soil and into underground water but can build up in fish or other organisms that live in contaminated water or that eat other contaminated animals. It has been used to combat termites and ants. It is also used as a flame retardant in plastics, rubber, paint, paper and electrical goods. Exposure: touching or ingesting contaminated soil near hazardous waste sites or ingesting contaminated fish or other animals living near hazardous waste sites. IARC has concluded that while there is inadequate evidence for the carcinogenicity of Mirex in humans, there is sufficient evidence in experimental animals. IARC has classified Mirex as a possible human carcinogen. Crustaceans are the most sensitive aquatic organisms, with larval and juvenile stages being the most sensitive. Delayed mortality is typical of Mirex poisoning in crustaceans.

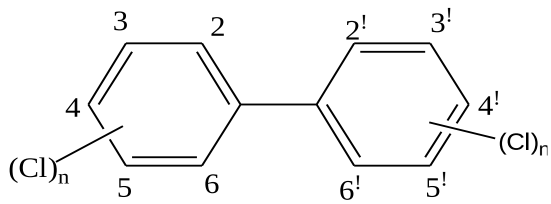
Toxaphene - Used primarily to control insect pests on cotton, cereal grains, fruits, nuts and vegetables. It has also been used to control ticks and mites in livestock. A solid or gas. In its original form it is a yellow to amber waxy solid that smells like turpentine. It may enter the air by evaporation. It does not dissolve well in water, so it is more likely to be found in air, soil, or sediment at the bottom of lakes or streams. Has a half-life in soil of up to 12 years, has been shown to bioconcentrate in aquatic organisms and undergoes long-range transport. Exposure of the general population is most likely through food, however levels detected are generally below maximum residue limits, while there is inadequate evidence for the carcinogenicity of Toxaphene in humans, there is sufficient evidence in animals. Brook trout exposed to Toxaphene for 90 days experienced a 46% reduction in weight at 0.039 µg/L, the lowest concentration tested. Egg viability in female trout was significantly reduced upon exposure to a concentration of 0.075 µg/L or more. Long term exposure to 0.5 µg/L reduced egg viability to zero. IARC has classified Toxaphene as a possible human carcinogen. It is banned in 37 countries and severely restricted in 11 others.

Chlordecone - Chlordecone was previously used as an insecticide to control agricultural pests, including slugs, snails, and fire ants. These uses has not been confirmed in Liberia. Chlordecone is highly persistent in the environment, has a high potential for bioaccumulation and biomagnification and based on physico-chemical properties and modelling data, chlordecone can be transported for long distances. It is classified as a possible human carcinogen and is very toxic to aquatic organisms. Chlordecone is well absorbed following oral exposure. Once absorbed, it is widely distributed and eventually concentrates in the liver. It is metabolized by humans and some animal species to chlordecone alcohol.

POLYCHLORINATED BIPHENYLS (PCBs) Old industrial POPs.

Molecular formula: (C12H(10-n)C1n, where n is within the range of 1-10)

Structural formula:



CAS No. 11097-69-1

USES: A polychlorinated biphenyl is a synthetic organic chemical compound of chlorine attached to biphenyl, which is a molecule composed of two benzene rings. There are 209 congeners of organochlorines with 1 to 10 chlorine atoms. The chemical formula for PCB is C12H10-xClx and about130 of the different PCB arrangements and orientations are used commercially. These organochlorines that are within the commercial cycle are called polychlorinated biphenyls. PCBs were used as coolants and insulating fluids used in transformers and capacitors, such as those used in old fluorescent light ballasts. PCBs were also used as ring and electronic plasticizers in paints and cements, stabilizing additives in flexible PVC coatings of electrical components, pesticide extenders, cutting oils, reactive flame retardants, lubricating oils, hydraulic fluids, and sealants (for caulking in schools and commercial buildings), adhesives, wood floor finishes, paints, de-dusting agents, waterproofing compounds, casting agents, vacuum pump fluids, fixatives in microscopy, surgical implants, and in carbonless copy ("NCR") paper. Because of its use as a plasticizer in paints and especially "coal tars" that were used widely to coat water tanks, bridges and other infrastructure pieces, it is recommended that before sandblasting to remove these materials the existing coal tar should be tested first to see if PCBs are present.

ENVIRONMENTAL FATE AND TOXICITY

Due to their low vapor pressure, PCBs accumulate primarily in the hydrosphere, in the organic fraction of soil, and in organisms. Despite their hydrophobicity, the immense volume of water in the oceans is still capable of dissolving a significant quantity of PCBs. However, a small volume of PCBs has been detected throughout the atmosphere, from the most urbanized areas that are the centers for PCB pollution, to regions north of the Arctic Circle. While the hydrosphere is the main reservoir, the atmosphere serves as the primary route for global transport of PCBs, particularly for those congeners with one to four chlorine atoms.

PCBs are toxic to fish, killing them at higher doses and causing spawning failures at lower doses. Research also links PCBs to reproductive failure and suppression of the immune system in various wild animals, such as seals and mink. Large numbers of people have been exposed to PCBs through food contamination. Consumption of PCB-contaminated rice oil in Japan in

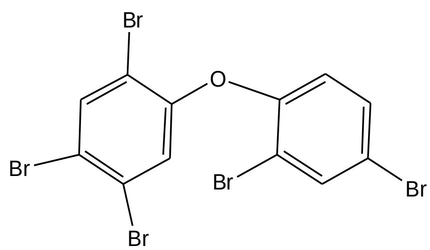
1968 and in Taiwan in 1979 caused pigmentation of nails and mucous membranes and swelling of the eyelids, along with fatigue, nausea, and vomiting. Due to the persistence of PCBs in their mothers' bodies, children born up to seven years after the Taiwan incident showed developmental delays and behavioral problems. Similarly, children of mothers who ate large amounts of contaminated fish from Lake Michigan showed poorer short-term memory function. PCBs also suppress the human immune system and are listed as probable human carcinogens.

COMMERCIAL PENTABROMODIPHENYL ETHER(C-PBDE)

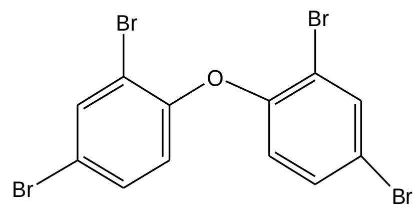
Molecular formula**:** $\mathbf{C_{12}H_5Br_5O}$

CAS Number: 32534-81-9

Structural formula:



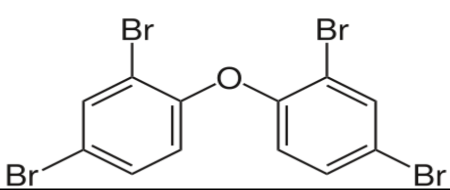
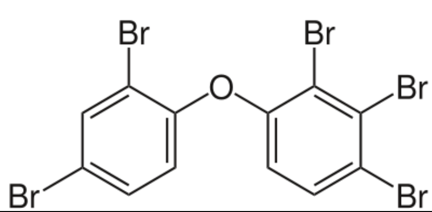
PENTABROMODIPHENYL ETHER

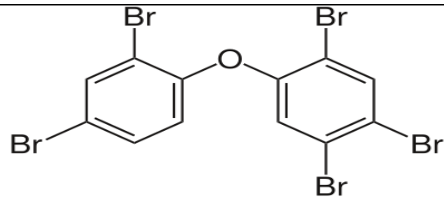
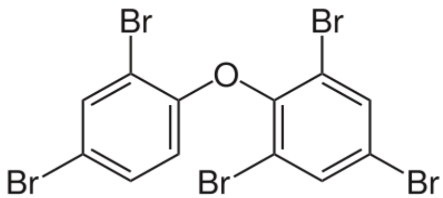
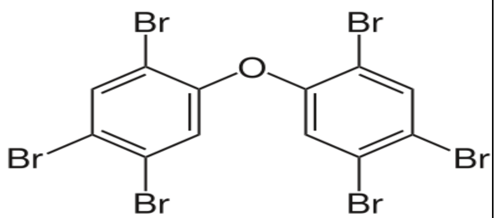
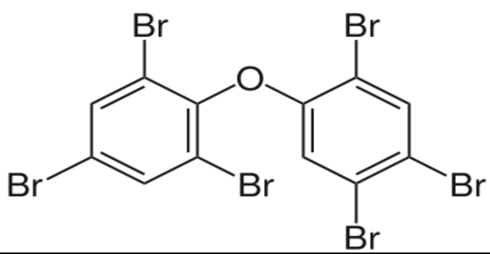


TETRABROMODIPHENYL ETHER

Commercial pentabromodiphenyl ether is a technical mixture of different polybrominated diphenyl ether congeners (related chemicals) with BDE -47 (2,2',4,4'-tetrabromodiphenyl ether) and BDE-99 (2,2',4,4',5-pentabromodiphenyl ether) as the most abundant.

COMPOSITION OF COMMERCIAL PENTABROMODIPHENYL ETHER

	STRUCTURE	**CONGENER**	**NAME**	**FRACTION**
1		BDE-47	2,2′,4,4′-tetra-bromodiphenyl ether	38–42%
2.		BDE-85	2,2′,3,4,4′-penta-bromodiphenyl ether	2.2–3.0 %
3.		BDE-99	2,2′,4,4′,5-penta-bromodiphenyl ether	45–49%

				
4		BDE-100	2,2′,4,4′,6-pent-bromodiphenyl ether	7.8–13 %
5		BDE-153	2,2′,4,4′,5,5′-hexa-bromodiphenyl ether	5.3–5.4 %
6		BDE-154	2,2′,4,4′,5,6′-hexa bromodiphenyl ether	2.7–4.5 %

USES: Commercial pentabromodiphenyl ether is a brominated flame retardant (BFR), one of a group of brominated organic substances that inhibit or suppress combustion in organic material. It has been used mainly in the manufacture of flexible polyurethane (PUR) foam for furniture and upholstery in homes and vehicles, packaging, and to a smaller extent non-foamed PUR in casings and electric and electronic equipment (EE). To some extent it has also been used in specialized applications in textiles and in various other uses. Because of the chemical and toxic properties of its main components, isomers of tetrabromodiphenyl ether (TetraBDE) and pentabromodiphenyl ether (PentaBDE), and their wide spread occurrence in the environment and in humans commercial pentabromdiphenyl ether causes concern in many regions in the world.

Commercial pentabromdiphenyl ether is not volatile but a thick liquid. However it can enter the air, water, and soil during their manufacture and use in consumer products. When C-PBDEs are suspended in air, they can be present as particles. They eventually return to land or water as the dust settles and are washed out by snow and rainwater. It is not yet possible to say how long C-PBDEs remain in the air. C-PBDEs do not dissolve easily in water, and therefore, high levels of C-PBDEs are not found in water. The very small amounts of C- PBDEs that do occur in water stick to particles and eventually settle to the bottom. Sediments at the bottom of bodies of water, such as lakes and rivers, generally act as reservoirs for decaBDEs, which can remain there for years. Some lower brominated PBDEs (e.g., tetra- and pentacongeners of PBDE) in water may build up in fish to low concentrations (about 10 ng to 1 μg of PDBE per gram of fresh fish [or 10x10-9–1x10-6 grams of PBDE per gram of fresh fish]).

ENVIRONMENTAL FATE AND TOXICITY.

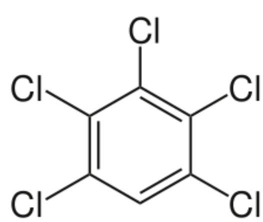
The producers of C-PBDE have reported that the major routes of C-PBDE release to the environment during production are filter waste and material rejected because it does not meet specifications, both of which are disposed of in landfills. Waste water releases of C-PBDE may also occur from spent scrubber solutions. The emissions to air from production of C-PBDE is assumed to be none or negligible. Modelling indicates that emissions during manufacture of products containing C-PentaBDE are minor in comparison to those associated with consumption.

C-PBDE may enter the body by ingestion or inhalation. It is "stored mainly in body fat" and may stay in the body for years. A 2007 study found that PBDE 47 (a tetraBDE) and PBDE 99 (a pentaBDE) had biomagnification factors in terrestrial carnivores and humans of 98, higher than any other industrial chemicals studied. In an investigation carried out by the WWF, "the brominated flame retardant chemical (PBDE 153), which is a component of the penta- and octa- brominated diphenyl ether flame retardant products" was found in all blood samples of 14 ministers of health and environment of 13 European Union countries.

PENTACHLOROBENZENE (PeCB)

Molecular formula. C_6HCl_5

Structural Formula



CAS Number : 608-93-5

USES: Pentachlorobenzene (PeCB) has been banned in many developed countries. However, various past uses or unintentional use of PeCB are mentioned in several literatures. PeCB was a component of a chlorobenzene mixture used to reduce the viscosity of PCB products employed for heat transfer. However, after regulations prohibiting new uses of PCB-containing dielectric fluids were introduced in 1980, the amount of pentachlorobenzene used for this purpose declined considerably in Canada. Based on the results of a survey, small amounts of pentachlorobenzene (40 kg during the first 6 months of 1992) were still imported into Canada in dielectric fluids for use in the maintenance of transformers. PCBs are still in use in some old electrical equipment in North America and Europe so that there is a small potential for release of PeCB from this source. It can be presumed that some PCBs are also still in use elsewhere in the world and some fraction of them contain PeCB. PCBs are being taken out of service in many countries of the world so that any related PeCB emissions are expected to decrease with time.

The use of PeCB as chemical intermediate is mentioned in WHO 1991 International Program on Chemicals Safety (IPCS). So far, only the use as an intermediate in the manufacture of pentachloronitrobenzene (quintozene, a fungicide) has been found in the literature. PeCB is present as an impurity in this fungicide. Quintozene has been commercially produced since the 1930s. In 2000 there were at least two producers of quintozene in the EU and several more suppliers. Quintozene was only authorized for use in the UK, Ireland, France, Spain and Greece. The Popular use of PeCB was in the production of quintozene, a fungicide, After mounting concerns were raised regarding the POP characteristics of pentachlorobenzene, manufacturers started to produce quintozene directly from nitrobenzene by chlorination. This method was adopted to avoid the use of PeCB in the production of quintozene .

ENVIRONMENTAL FATE AND TOXITY

Pentachlorobenzene (PeCB) can be photo-oxidized in the atmosphere, largely through reactions with hydroxyl (OH) radicals. There are no experimental data on atmospheric degradation, but the estimated half-life of PeCB is 45 to 467 days. For PeCB, the calculated half-life in air based on reaction with OH-radicals is 277 days estimate a half-life in air of 65 days based on modelling data. This estimate is the result of degradation as well as dry and wet deposition and gaseous exchange with various surfaces. The atmospheric half-life of PeCB due to the degradation process only is estimated to be 155 days.

Experimental data on degradation of PeCB in water are lacking. Hoever, PeCB is expected to dissipate from the water phase to the sediment or into the air. PeCB is persistent in soils and sediments under aerobic conditions. In anaerobic sediment-water slurries, PeCB is considered persistent, except at temperatures above 10°C in combination with low organic matter contents. Higher organic matter contents seem to drastically increase the persistency. Actual field measurements of PeCB may overestimate persistency as a result of formation of PeCB from HCB. The true field half life of PeCB is estimated around 6 years in organic soil and sediment in the temperate zone. PeCB should be considered as persistent given the magnitude of estimated and experimental half-lives in atmosphere, soils, sediments, and water. Persistence in the environment depends on the rate of photo-oxidation, the presence of oxygen and organic matter.

Pentachlorobenzene is highly hydrophobic. Therefore, it can be assumed that the compound has a high bioaccumulation potential. This is confirmed by the high bioaccumulation factors of PeCB in fish, mollusca crustacea. Due to the high partition coefficient(logKow) and the fact that biotransformation may be insignificant, the compound may also have a biomagnification potential.

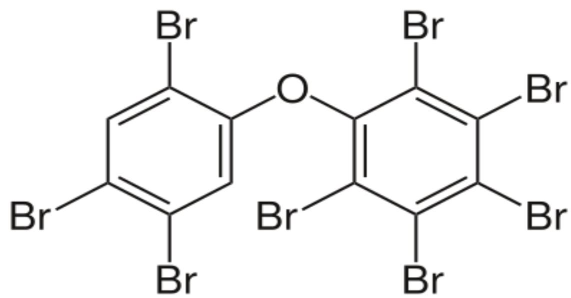
Occupational exposure to PeCB may be through inhalation and dermal contact with this compound at workplaces where PeCB is produced or used. Examples are wood treatment plants, dielectric fluid spill and cleanup, municipal solid waste incinerators, hazardous waste incinerators, and magnesium production plants. Exposure may also arise in occupational settings where the pesticide quintozene is produced and used. The general population may be exposed to PeCB via inhalation of ambient air, ingestion of food and drinking water. Case reports of adverse effects in individuals, or epidemiological studies of populations exposed to PeCB have not been identified.

COMMERCIAL OCTABROMODIPHENYL ETHER (c-OctaBDE)

(Hexabromodiphenyl ether and heptabromodiphenyl ether)

Molecular formula **$C_{12}H_2Br_8O$**

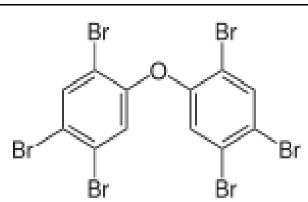
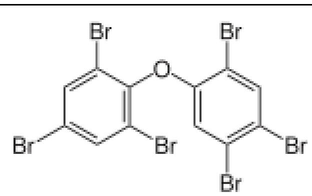
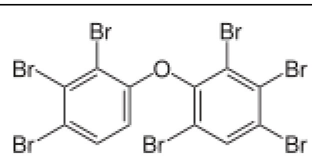
CAS Number : **32536-52-0**

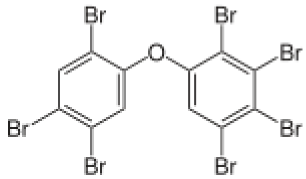
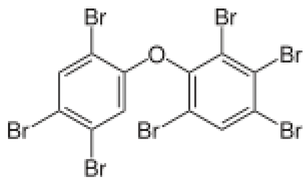
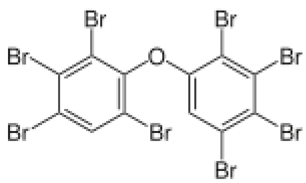
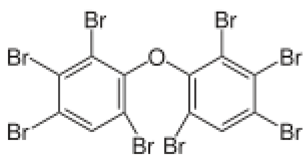
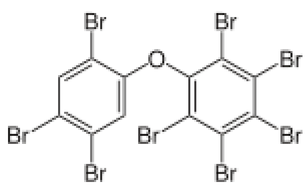
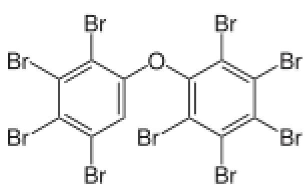
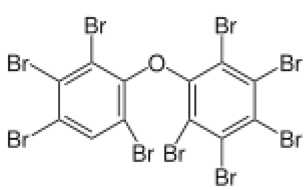


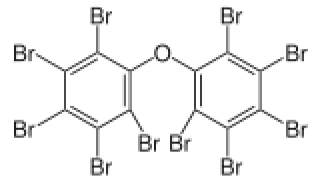
Structural formula

Commercial octaBDE (also known as "Octabrom") is a technical mixture of different PBDE congeners having an average of 7.2 to 7.7 bromine atoms per molecule of diphenyl ether. The predominant congeners in commercial octaBDE are those of heptabromodiphenyl ether and octaBDE. The term octaBDE alone refers to isomers of octabromodiphenyl ether (PBDE congener numbers 194–205)

3.5.1 COMPOSITION OF OCTABROMODIPENYL ETHER. (c-OctaBDE)

	STRUCTURE	CONGENER	NAME	FRACTION
1		BDE-153	2,2′,4,4′,5,5′-hexa-bromodiphenyl ether	0.15–8.7%
2		BDE-154	2,2′,4,4′,5,6′-hexa-bromodiphenyl ether	0.04–1.1%
3		BDE-171	2,2′,3,3′,4,4′,6-hepta-bromodiphenyl ether	0.17–1.8%

4		BDE-180	2,2′,3,4,4′,5,5′-hepta-bromodiphenyl ether	n.d.–1.7%
5		BDE-183	2,2′,3,4,4′,5′,6-hepta-bromodiphenyl ether	13–42%
6		BDE-196	2,2′,3,3′,4,4′,5,6′-octa-bromodiphenyl ether	3.1–10.5%
7		BDE-197	2,2′,3,3′,4,4′,6,6′-octa-bromodiphenyl ether	11–22%
8		BDE-203	2,2′,3,4,4′,5,5′,6-octa-bromodiphenyl ether	4.4–8.1%
9		BDE-206	2,2′,3,3′,4,4′,5,5′,6-nona-bromodiphenyl ether	1.4–7.7%
10		BDE-207	2,2′,3,3′,4,4′,5,6,6′-nona-bromodiphenyl ether	11–12%

11		BDE-209	Deca-bromodiphenyl ether	1.3–50%

USES: The polybrominated diphenyl ethers in general are used as flame retardants of the additive type. They are physically combined with the material being treated rather than chemically combined (as in reactive flame retardants). This means that there is the possibility that the flame retardant may diffuse out of the treated material to some extent. Industry indicates that octabromodiphenyl ether is always used in conjunction with antimony trioxide. In Europe, it is primarily used in acrylonitrile-butadiene-styrene (ABS) polymers at 12-18% weight loadings in the final product.

Around 95% of the total octabromodiphenyl ether supplied in the EU is used in ABS styrene production. Other minor uses, accounting for the remaining 5% use, include high impact polystyrene (HIPS), polybutylene terephthalate (PBT) and polyamide polymers, at typical loadings of 12-15% weight in the final product.

In some applications, the flame retardant is compounded with the polymer to produce pellets (masterbatch) with slightly higher loadings of flame retardant. These are then used in the polymer processing step to produce products with similar loadings as given above.

The flame retardant polymer products are typically used for the housings of office equipment and business machines. Other uses that have been reported for octabromodiphenyl ether include nylon and low density polyethylene, polycarbonate, phenol-formaldehyde resins and unsaturated polyesters and in adhesives and coatings. Assuming that the commercial OctaBDE is not longer produced, the releases to the environment must be associated to historical processes, as well as to releases during the service life of articles containing the commercial mixtures and at the end of article service life during disposal operations.

ENVIRONMENTAL FATE AND TOXICITY.

OctaBDE is released by different processes into the environment, such as emissions from the manufacture of octaBDE-containing products and from the products themselves. Elevated concentrations can be found in air, water, soil, food, sediment, sludge, and dust. In the environment, "photolysis, anaerobic degradation and metabolism in biota" can cause debromination of octaBDE, which produces PBDEs with fewer bromine atoms "which may have higher toxicity and bioaccumulation potential.

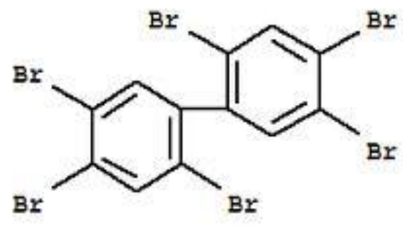
The presence of components of commercial Octa BDE in remote areas is considered the best demonstration for the potential for long range transport of these chemicals. As debromination in the environment and biota has been demonstrated, hypothetically, the presence of Hexa to NonaBDEs could be explained by a long range transport of DecaBDE and its subsequent debromination, however, it is very unlikely to assume a long range transport only for DecaBDE and not also for the Nona to Hexa congeners.

HEXABROMOBIPHENYL (HBB)

Molecular formula: $C_{12}H_4Br_6$

CAS Number : 36355-01-8

Structural formula:



USES: Hexabromobiphenyl belongs to a wider group of polybrominated biphenyls. The term polybrominated biphenyls or polybromobiphenyls (PBBs) refers to a group of halogenated hydrocarbons, formed by substituting hydrogen by bromine in biphenyl. These intentionally produced chemicals have mainly been used as flame retardants in synthetic fibres and plastics. Technical PBBs contain several PBB compounds, isomers and congeners, hexabromobiphenyl being one of the main components.

Hexabromobiphenyl has been identified as a Persistent Organic Pollutant (POP) chemical under the Protocol to the Convention on Long-range Transboundary Air Pollution (CLRTAP) on Persistent Organic Pollutants and has been listed under Anex A to the Stockholm Convention. The provisions of the Protocol oblige Parties to phase out all production and uses of hexabromobiphenyl.

In the United States and Canada, hexabromobiphenyl which is also referred to as (FireMaster was the principal PBB product. It was used as a fire retardant in three main commercial products: acrylonitrile-butadiene-styrene (ABS) thermoplastics for constructing business machine housings and in industrial (e.g. motor housing), and electrical (e. g. radio and TV parts) products: as a fire retardant in coatings and lacquers, and in polyurethane foam for auto upholstery. Approximately 5 million tonnes of HBB were produced in the USA from 1970 to 1976; 98 per cent was used as FireMaster BP-6 and the rest as FireMaster FF-1. The amount of hexabromobiphenyl used in polyurethane foam for automobile upholstery could not be quantified because it was popularly used.

The two larger consumers ceased using hexabromobiphenyl (one of these in 1972) because PBBs did not decompose in the ultimate incineration of scrapped automobiles.

ENVIRONMENTAL FATE AND TOXICITY.

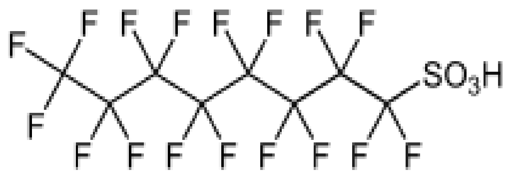
Hexabromobiphenyl is highly persistent in the environment, highly bioaccumulative and has a strong possibility for long-range environmental transport. It has been reported to be persistent under field conditions. Soil samples from a former PBB manufacturing site, analyzed several years after accidental release, still contained PBBs of which HBB is part. However, the congener composition was different, indicating partial degradation of the PBB residue in the soil samples. According to the EHC Review, follow-up surveys over a three year period following the termination of PBB production showed no significant decline in PBB levels in sediments from a river. In laboratory investigations, mixtures of PBBs appear to be fairly resistant to microbial degradation. As hexabromobiphenyl is classified as a possible human carcinogen and has other chronic toxic effects, the Committee recommended its listing as a POP.

PERFLUOROOCTANE SULFONIC ACID (PFOS), ITS SALTS AND PERFLUOROOCTANE SULFONYL FLUORIDE (PFOS-F)

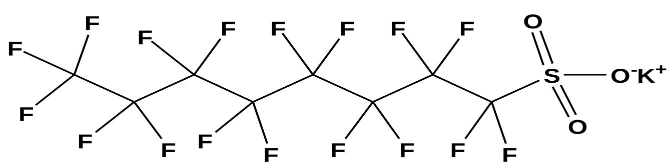
Molecular formula : C8HF17O3S

CAS Number: 1763-23-1

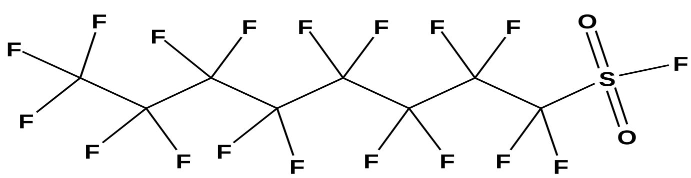
Structural formula:



Perfluorooctane sulfonic acid



Salt of perfluorooctane sulfonic acid



Perfluorooctane sulfonyl fluoride PFOSF

USES: PFOS is a fully fluorinated anion, which is commonly used as a salt in some applications or incorporated into larger polymers. PFOS is produced synthetically from PFOSF, and PFOS can be derived from its salts when dissolved. The term "PFOS-related substances" is used for all substances that contain one or more PFOS groups (C8F17SO2) and that can, or are assumed to, be degraded to PFOS in the environment. These PFOS-related substances are restricted through the listing of PFOSF, the basic material for their manufacture, and the listing of PFOS in the Convention. PFOSF is an intermediate material for production of all C8-perfluorinated alkyl sulfonate compounds, and they are all restricted to the uses

The majority of PFOS-related substances are polymers of high molecular weights in which PFOS is only a fraction of the polymer and final product.. Although the net contribution of individual PFOS-related substances to the total environmental load of PFOS cannot be readily predicted, there is a potential that any molecule containing the PFOS carbon chain could be a precursor to PFOS. PFOS can be formed by environmental microbial degradation or by metabolism in larger organisms from PFOS-related substances.

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 derivatives are or have been used in a wide variety of applications such as textiles and leather products, metal plating, food packaging, fire fighting foams, floor polishes, denture cleansers, shampoos, coatings and coating additives, in the photographic and photolithographic industry, medical devices and in hydraulic fluids in the aviation industry

ENVIRONMENTAL FATE AND TOXICITY.

The C8F17 subunit of PFOS is hydrophobic and lipophobic, like other fluorocarbons, while the sulfonic acid/sulfonate 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. 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.

PFOS and its derivatives have been shown to affect the immune system of male mice at a blood serum concentration of ~90 parts per billion, raising the possibility that highly exposed people and wildlife are immuno compromised. Occupationally exposed individuals have an average level of PFOS over 1000 parts per billion. A variety of wildlife species have had PFOS levels measured in egg, liver, kidney, serum, and plasma samples.

The levels observed in wild animals are considered sufficient to alter health parameters. 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.

Appendix B

Sample Stakeholder Questionnaire

ENVIRONMENTAL PROTECTION AGENCY
P. O. BOX 4024
4th STREET SINKON TUBMAN BOULEVARD
1000 MONROVIA, 10 LIBERIA

ENABLING ACTIVITIES TO REVIEW AND UPDATE THE NATIONAL IMPLEMENTATION PLAN (NIPs) FOR THE STOCKHOLM CONVENTION ON PERSISTENT ORGANIC POLLUTANTS (POPs) IN LIBERIA.

Part I: **INVENTORY QUESTIONNIRE ON OLD AND NEW PERSISTENT ORGANIC POLLUTANTS AS (POPs)**

PLEASE PRINT

1. Full name of entity:____

2. Address : ____
____
____

3. Activities: ____
____

4. Name of Manager ____
Contact: ______________________________
E.mail: ______________________________

5. Provide a check mark √.
Are you a chemical ____Producer ____Importer _____Exporter

____Distributor ____ Wholesaler _____Retailer

___ NGO ____End-user

___Other, please explain below
____
____
____

6. Are you sure that the chemicals you order are the product delivered?___Yes, ____ No

7. Are you sure your product has not been adulterated? _____ Yes, ____No

8. Do you know what to do in case of accidental leakage or spillage? _____Yes, _______No

9. Do you teach your customers how to handle the product(s) safely? _____ Yes _______No

10. Do you have the MSDS (material safety data sheet) for all the chemicals you are handling? _________ Yes _________No.

11. Do you know how to use MSDS for chemicals? ______ Yes, ______ No

12. Do you give copy of the MSDS to each customer who purchases chemical from you?
_____ Yes, _______No.

13. Do you know about the industrial chemicals that are considered as POPs ___ Yes___No

14. Are you knowledgeable of the use of these chemicals? _____ Yes: ______No

15. Do you have a functional laboratory in your institution?_____ Yes _____No

16. Do you know of any legal document/policy with regards to industrial POPs in Liberia?
________ Yes ________No.

17. Do you know of any government regulatory agency in Liberia that is concerned with POPs? ___ Yes ____No.

18. Does this institution have written guidelines concerning banned industrial POPs?
___ Yes ____No

19. Is there any standard policy established between institution and employees in case of any accident during handling? _____ Yes ______ No

Part II: Inventory: This portion of the questionnaire is intended for those who are handling chemicals. If you are handling(selling or manufacturing) chemicals, escape this portion. However, if you are dealer in chemicals, please complete the table below

No.	Name of Chemical	Amount imported or produced in ton/kg	Major end user	What is main use of the chemical?
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
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31				
32				
33				
34				
35				
36				
37				
38				
39				
40				

NOTE: If the quantity of chemical you are handling exceeds 40, please photocopy this page and continue the list.

Part III: Inventory on materials that contain polybrominated diphenyl ether (PBDEs), perfluorooctane sulfonic acid (PFOs) and other manufactured POPs contaminants.

Name of items	Quality	Manufacturing date	Quantity
Computer			
Central processing unit (CPU)			
Carpet roll			
Furniture			
Vehicles before 2014 model			
Telephones			
Airplane			
Cell phone			
Plastic like materials (play toys)			
Flood mat			

1. Do you have knowledge regarding storage of chemicals?___ Yes _____ No.

2. Do you know the expiring date of the chemicals you are handling? ____Yes ____No.

3. What do you do when your product expired? a.____I dump it/them b____I burnit/themYes Any method not mentioned

____

____

4. How do you dispose of expired chemicals?_____________________________________

____

____

____

5. Have you dealt with chemicals such as or products that contain: hexabromodiphenyl ether _______________, heptabromodiphenyl ether__________, octabromodiphenyl ether_______ ,Pentachlorobenzene________, Perfluorooctane sulfonic acid and its salt (PFOs)_________, perfluorooctane sulfonyl flouride (PFOs-F)________, tetrabromodiphenyl ether_________ and pentabromodiphenyl ether______________.

REFERENCES.

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2. Polybrominated diphenyls ethers as global pollutants.

http://www.pops.int/documents/meetings/cop_1/chemlisting/pentaBDEfinal.pdf

3. Used and end-of-life electrical and electronic equipment imported into Liberia

http://www.basel.int/Portals/4/Basel%20Convention/docs/eWaste/E-waste_Africa_Project_NationalAssessment_Liberia.pdf

4. e-Waste Africa project of the Secretariat of the Basel Convention. (2012)

5. http://siteresources.worldbank.org/INTPOPS/214574-1115813449181/20486510/PersistentOrganicPollutantsAResourceGuide2001.pdf

6. http://www.epa.gov/ttn/atw/hlthef/hexa-ben.html

7. http://www.atsdr.cdc.gov/substances/toxsubstance.asp?toxid=26

8.http://www.pops.int/documents/meetings/poprc/drprofile/drme/DraftRME_PeBDE.pdf

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