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Matters related to the implementation of the Convention: measures to reduce or eliminate releases from intentional production and use: polychlorinated biphenyls

Consolidated assessment of efforts made towards the elimination of polychlorinated biphenyls

Note by the Secretariat

As referred to in the note by the Secretariat on polychlorinated biphenyls (UNEP/POPS/COP.8/6), in its leadership role within the Polychlorinated Biphenyls Elimination Network (PEN), the Chemicals and Waste Branch of the Division of Technology, Industry and Economics of the United Nations Environment Programme, in cooperation with the Secretariat and in consultation with the PEN advisory committee, developed a consolidated assessment of efforts made towards the elimination of polychlorinated biphenyls, as set out in the annex to the present note. The present note, including its annex, has not been formally edited.

* UNEP/POPS/COP.8/1.

Annex

CONSOLIDATED ASSESSMENT OF EFFORTS MADE TOWARD THE ELIMINATION OF POLYCHLORINATED BIPHENYLS

UNEP/DTIE
CHEMICALS AND WASTE BRANCH
JANUARY 2016

Photo on title page:
PCB-containing equipment after a fire accident

Source: Field visit of the interagency team (November, 2015)

Report prepared by:
UNEP Chemicals and Waste Branch, DTIE
Science and Risk Unit
International Environment House
11-13, chemin des Anémones
CH-1219 Châtelaine (GE)
Switzerland
Email: science.chemicals@unep.org

Special thanks is due to Heidelore Fiedler

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Acronyms and Abbreviations

BCRC-AF	Basel Convention Regional Centre for Francophone Africa
BRS Secretariat	Secretariat of the Basel, Rotterdam and Stockholm Conventions
CLEEN	Chemical Legislation European Enforcement Network
CEE	Central and Eastern Europe
COP	Conference of the Parties
DPRK	Democratic People's Republic of Korea
DTIE	Division of Technology, Industry and Economics
EU	European Union
GEF	Global Environment Facility
GMP	Global Monitoring Plan for POPs
GRULAC	Latin America and the Caribbean Countries Group
NAFTA	North American Free Trade Agreement
NIPs	National Implementation Plans
PAS	Passive air samplers
PBBs	Polybrominated biphenyls
PCB	Polychlorinated biphenyl(s)
PCTs	Polychlorinated terphenyls
PEN	PCB Elimination Network
PIFs	Project identification forms
POPs	Persistent Organic Pollutants
PUF	Polyurethane foam
TEQ	Toxic equivalents
UN Comtrade	United Nations Commodity Trade Statistics Database
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organization
USA	United States of America
WEOG	Western European and Others Group
WHO	World Health Organization

Executive Summary

At its sixth meeting, in Geneva, Switzerland, 28 April-10 May 2013, the Conference of the Parties (COP) to the Stockholm Convention on Persistent Organic Pollutants (POPs) requested the BRS Secretariat[1] to prepare a report on progress toward the elimination of polychlorinated biphenyls (PCB) on the basis of the third national reports submitted by Parties pursuant to Article 15 of the Stockholm Convention[2].

In its leadership role within the PCB Elimination Network (PEN), UNEP Chemicals and Waste Branch[3], in cooperation with the BRS Secretariat and in consultation with the PEN advisory committee, developed a preliminary assessment of efforts made toward the elimination of PCB, taking into account national reports submitted by parties pursuant to Article 15 of the Convention and other relevant sources of information. It was submitted to the seventh meeting of the COP as document UNEP/POPS/COP.7/INF/9. In decision SC-7/3 on PCB, the COP requested the Secretariat to consolidate the preliminary assessment, taking into consideration any additional third national reports submitted and any other relevant information, in accordance with the framework for the effectiveness evaluation of the Stockholm Convention.

As in the case of the preliminary assessment, the objective of this consolidated assessment is to summarize available information on the amounts of PCB produced, the amounts that have been eliminated to date, and the amounts that still need to be eliminated in order to determine how much progress has been made towards the elimination of PCB.

As the information available from the third national reports was found insufficient to fulfil the mandate, additional sources of information were consulted, including national implementation plans (NIPs), national reports under the Basel Convention, Global Environment Facility (GEF) projects, and technical reports. Moreover, a survey was conducted among Basel and Stockholm Convention Regional Centers, UNEP Regional Offices, GEF implementing agencies, and the advisory committee of the PEN. Data were systematically collected from these sources and assessed by making extrapolations, harmonizing units, avoiding double counting, *etc*. In a last step, the total mass of PCB at various stages in the life-cycle was obtained. As compared to the preliminary assessment, new sources of information have been included, as elaborated upon in section 2.1 below. Moreover, the methodology has been further refined with the aim of providing more accurate estimates for the variables of interest.

In compiling and evaluating the data, numerous challenges were encountered, resulting in some important limitations as regards the statistical analysis and the conclusions to be drawn: Most notably, the vast majority of national inventories were found to be preliminary and very limited in scope and coverage. Information on already executed elimination was equally incomplete. For some countries, no information was available. This report, though consolidated, remains preliminary in nature and the estimates are subject to a high degree of uncertainty. Nonetheless, the assessment is sufficient to provide a general idea of the progress towards eliminating PCB and can thus be used to evaluate the effectiveness of the Stockholm Convention with regard to PCB.

It is estimated that between 1 and 1.5 million tonnes of technical grade PCB have been produced by a small number of countries (12) and companies (17) since the late 1920s. This estimate includes the United States of America (USA) and Italy, both of which are not Parties to the Stockholm Convention. Available information suggests that production of PCB is ongoing in one country. It is important to note that due to dilution and cross-contamination, the mass of liquids and equipment containing or contaminated with PCB is much larger than the amounts of PCB produced.

[1] The Secretariat of the Basel, Rotterdam and Stockholm Conventions

[2] Conference of the Parties to the Stockholm Convention, 2013

[3] The Chemicals Branch of the United Nations Environment Programme's (UNEP) Division of Technology, Industry and Economics

According to the data provided in the first, second and third national reports, ca. 628 thousand tonnes of liquids and equipment containing or contaminated with PCB at concentrations higher than 0.005 % and volumes larger than 0.05 litres have been eliminated to date. However, there is significant double counting; for example, substantial shares of the amounts reported in the second and third national report may already have been reported in the first. By contrast, based on the above-mentioned additional sources, this report estimates that ca. 3 million tonnes have been eliminated by Parties to the Convention to date, mostly transformers and capacitors. Expert judgment suggests that the actual amounts eliminated are much higher, as no quantitative data was available for a large number of countries. According to available data, ca. 70 % of the total was eliminated after 2004. The largest amounts were reportedly eliminated in 2011. Based on the limited data available, it is estimated that GEF-funded projects account for the elimination of at least 23 thousand tonnes to date.

The progress in eliminating PCB varies considerably across UN regions. About 68 % of the eliminated mass, equivalent to more than 2 million tonnes, was from the Asia-Pacific Region. The WEOG follows with ca. 24 %, Central and Eastern Europe (CEE) with ca. 4 %, the Latin American and Caribbean Group (GRULAC) with ca. 3 % and Africa with less than 1 %. It is important to note that Japan reported about two thirds of the amounts already eliminated. Expert judgement suggests that this is an indication that other countries underreported significantly. The regions also followed different approaches in disposing of PCB wastes. While GRULAC, the CEE and the African Region exported most of their waste for elimination to other regions, WEOG and the Asia-Pacific Region eliminated the large majority of their waste either domestically or within the region.

The total mass of PCB liquids and equipment that still needs to be eliminated is estimated at *ca*. 14 million tonnes. Where the type of equipment was clearly specified, transformers account for the largest share of the total mass. Data on the amounts of PCB in open applications are very scarce and limited to very few developed countries. The overall estimate is at best indicative, given the many limitations discussed above. Meanwhile, expert judgement suggests that the actual amounts still in need of elimination are much higher.

Approximately 77 % of the total mass of liquids and equipment containing or contaminated with PCB has been reported by the Asia-Pacific Region, followed by GRULAC and CEE (*ca*. 7 %), the WEOG (ca. 6 %), and the African Region (*ca*. 4 %). This large discrepancy between the Asia-Pacific Region and the other regions can to a far extent be explained by varying quality in reporting, in particular the comprehensive data reported by Japan. Removing Japan from the data set yields a much more balanced picture. For the African Region in particular, but also for GRULAC, data are incomplete and need improvement. Meanwhile, in the case of WEOG, only small amounts in closed applications remain to be eliminated. Expert judgement suggests that the amounts reported for the Asia-Pacific region are more accurate than those reported by the other regions, possibly with the exception of the WEOG. Again, Japan provided a much more comprehensive inventory than other countries. Removing Japan from the data set decreases the total mass still to be eliminated to ca. 2.5 million tonnes. The high figures reported by Japan should be seen as an indication that most, if not all other countries reported quantities that are unrealistically low, meaning that the total mass still to be eliminated is probably much larger than the estimated 14 million tonnes.

Based on these data, it is estimated that approximately 17 % of the total amount of PCB has been eliminated to date – about 83 % remain to be eliminated. The African Region has the longest way ahead towards achieving the goal of eliminating PCB: *Ca*. 98 % of the liquids and equipment containing or contaminated with PCB still need to be eliminated. The approximate shares lie at 86 % for the Asia-Pacific Region and GRULAC, 81 % for CEE and 36 % for WEOG.

Further work will be necessary in order to refine the present analysis as well as to incorporate additional data as they become available. Despite the preliminary character of this assessment, a number of conclusions and recommendations can be drawn: The limited data available are sufficient to highlight the need to expedite and intensify efforts to eliminate PCB to meet the 2025/2028 goals of the Stockholm

Convention. While some progress – although difficult to quantify – has been made towards the elimination of PCB, the majority of countries (with some notable exceptions) are currently not on track to achieve the environmentally sound management of PCB by 2028. Presumably, the challenge of achieving this objective has been underestimated.

Large amounts of PCB have already been released to the environment. In order to move forward, it will be necessary to leverage substantial and additional financial, human and technical resources. There is an abundance of expertise and materials developed within the framework of former and existing PCB projects that can be used in achieving the objectives. Countries will need to develop and implement comprehensive national action plans and strengthen regulatory frameworks. It is strongly recommended that steps are taken to ensure that comprehensive, clear, reliable and well-structured data become available. For this purpose, inventories need to be completed, national databases established, methodologies harmonized, reporting improved and the NIP guidance amended. It is also timely to address open applications. In addition, steps need to be taken to ensure that the production of PCB is phased out as soon as possible. This may need to include technology transfer.

1. Introduction and Mandate

The Stockholm Convention on POPs[4] entered into force in May 2004. It aims to eliminate the production, use, and trade of POPs in order to protect human health and the environment. Among others, the Convention obliges Parties to eliminate the use of PCB in equipment by 2025 (Article 3, paragraph (1) (a)). Moreover, Parties have to make determined efforts designed to lead to environmentally sound waste management of liquids containing PCB and equipment contaminated with PCB having a PCB content above 0.005 % as soon as possible but no later than 2028, subject to review by the COP (Article A, Part II, paragraph (e)).

At its sixth meeting, held in Geneva, Switzerland from 28 April to 10 May 2013, the COP to the Stockholm Convention, through decision SC-6/6 on PCB requested the Secretariat to prepare a report on progress towards the elimination of PCB[5]. The report has to be prepared in accordance with paragraph (h) of part II of Annex A to the Convention, which notes that the COP shall review progress towards elimination of PCB at five year intervals or other period, as appropriate, taking into account the reports on progress in eliminating PCB submitted by Parties. As stipulated in Article 16 of the Convention, its effectiveness is to be evaluated at regular intervals in order to assess whether the measures adopted by the Convention and implemented by its Parties are an effective tool to protect human health and the environment from the adverse effects of POPs.

The report was to be compiled on the basis of the third national reports submitted by Parties pursuant to Article 15, according to which Parties shall, *inter alia*, provide to the Secretariat statistical data on their total quantities of production, import and export of the chemicals listed in Annex A and Annex B, including PCB. The Secretariat was further requested to submit the report to the COP for evaluation at its seventh meeting, to be held in May 2015. That information, which has been made available in full (see UNEP/POPS/COP.7/INF/36) and summarized (see UNEP/POPS/COP.7/27), was insufficient to assess progress toward the elimination of PCB.

In its leadership role within the PEN, UNEP Chemicals and Waste Branch, in cooperation with the BRS Secretariat and in consultation with the PEN advisory committee, developed a preliminary assessment of efforts made toward the elimination of polychlorinated biphenyls, taking into account national reports submitted by parties pursuant to Article 15 of the Convention and other relevant sources of information. It was submitted to the seventh meeting of the COP as document UNEP/POPS/COP.7/INF/9. In decision SC-7/3 on PCB, the COP requested the Secretariat to consolidate the preliminary assessment, taking into consideration any additional third national reports submitted and any other relevant information, in accordance with the framework for the effectiveness evaluation of the Stockholm Convention.

The draft preliminary assessment was presented to and discussed with the members of the Advisory Committee of the PEN at its fifth meeting, held on 26-27 November 2014 in Geneva, Switzerland, and subsequently refined according to the recommendations received by the experts. The draft consolidated assessment was discussed in depth at the 'Expert Meeting on the Effectiveness Evaluation of Implementation of the Stockholm Convention for PCB' as well as the 'Sixth Meeting of the Advisory Committee of the PEN', held back-to-back on 14-16 December 2015 in Brno, Czech Republic.

The objective of this consolidated assessment is to summarize available information on the amounts of PCB produced, the amounts that have been eliminated and the amounts that still need to be eliminated, in order to determine how much progress has been made towards the elimination of PCB. Several elements need to be included in such an analysis: First, it is necessary to gain an understanding of how much PCB has been produced and, to the extent possible, how much liquids and equipment has been manufactured with PCB. Next, the report provides an estimate of the amounts that have already been eliminated. Finally, an estimate of the amounts that are still in need of elimination is given. The

[4] UNEP, 2001
[5] Conference of the Parties to the Stockholm Convention, 2013

substantive part of this report is structured according to these three elements. The discussion of the data is preceded by a discussion of the sources of information and methodology relied upon for this report as well as the limitations and challenges that were encountered in gathering data and conducting the statistical analysis. As compared to the preliminary assessment, new sources of information have been included, as elaborated upon in section 2.1 below. Moreover, the methodology has been further refined with the aim of providing more accurate estimates for the variables of interest.

It is important to note, that the monitoring of concentrations of PCB in humans and in the environment and the identification of trends in such concentrations can provide valuable insights to determine whether the efforts of Parties to identify and manage PCB in an environmentally sound manner translate into tangible benefits. Such activities are being undertaken within the context of the Global Monitoring Plan on POPs (GMP)[6] and related GEF-funded projects carried out by UNEP Chemicals and Waste Branch[7], the biennial Global Interlaboratory Assessments on POPs[8], the WHO Human Milk Surveys[9], and other relevant national, regional and global initiatives.

This report is an initial assessment based on the limited data available. Inventories are mostly of preliminary nature and not suited to give a precise picture. The same applies to reporting on the amounts of PCB that have been eliminated. The estimates given below can therefore only be made with a high degree of uncertainty. While the findings should be interpreted with caution, they are sufficient to give a general idea of the progress towards PCB elimination and can thus be used to evaluate the effectiveness of the Stockholm Convention with regard to PCB.

Based on the conclusions that can be drawn from these findings, the report provides recommendations on the way forward towards elimination of PCB. Many countries have made efforts to identify and eliminate existing stockpiles of liquid and solid PCB wastes. However, progress has been limited and varies considerably across regions. In order to achieve the objective of the Stockholm Convention, it will be necessary to upscale efforts substantially, including by leveraging additional funding for the identification and elimination of PCB wastes and making elimination technologies available to developing countries and countries with economies in transition. Parties will also need to address open applications which have so far not received sufficient attention.

[6] For more information, see Secretariat of the Basel, Rotterdam and Stockholm Conventions, 2015a

[7] For more information, see UNEP Chemicals and Waste Branch, 2015a

[8] For more information, see UNEP Chemicals and Waste Branch 2015b

[9] For more information, see Secretariat of the Basel, Rotterdam and Stockholm Conventions, 2015b and WHO, 2015

2. Methodology

2.1. Sources of Information

According to this report's mandate, the evaluation of progress towards eliminating PCB is to be based on the third national reports under the Stockholm Convention. Deadline for submission was 31 August 2014; however, a large share was submitted after this date. Among others, the reports contain information on Parties' inventories and progress in eliminating PCB. While useful data are available from these reports, they are not sufficient to draw a comprehensive picture of the situation.

For many countries, little, if any, relevant quantitative information is available. As of 25 November 2015, out of the 179 Parties to the Convention, only 69 submitted the third national reports[10]. For those that are available, reporting is often fragmented and incomplete. Moreover, despite the standardized reporting format, there is considerable variance in how data are presented (many countries use the comments section, rather than the table, thereby reverting to their own format). Finally, closer examination of the data reveals instances where the units of measurement have apparently been confused[11].

Overall, the data available from the third national reports were found insufficient to assess efforts made towards the elimination of PCB. Therefore, additional sources of information had to be consulted in order to (a) prepare a comprehensive report on quantitative data and (b) to fill the gaps where available information was incomplete. The following additional sources have been consulted:

- The first and second national reports submitted by Parties under the Stockholm Convention reporting procedure. Deadlines for submission had been set at 31 December 2006 and 31 October 2010, but were extended to 31 July 2007 and 31 July 2011, respectively. 45 Parties submitted their first national report and 95 the second report[12].
- Initial and – where available –updated NIPs[13]: According to Article 7 of the Stockholm Convention, Parties are required to prepare and submit a plan for the implementation of their obligations under the Convention, and to review and update it, as appropriate, on a periodic basis. While general in scope, the NIPs include sections on PCB, including information on – often preliminary – inventories as well as amounts of PCB eliminated. As of 25 November 2015, 162 Parties have submitted their first NIP and 30 of them the reviewed and updated one.
- National reporting under the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal[14]: Parties to the Basel Convention provide data on imports and exports of hazardous wastes and other wastes, including PCB wastes at 0.005 %. The relevant codes are A1180[15], A1190[16] and A3180[17]. Data were available for the years 2009, 2010, 2011, 2012 and 2013.
- PCB-related projects funded by the GEF: These projects typically include components such as the development of national inventories, the environmentally sound management of PCB and the elimination of national stockpiles of PCB. Implementing agencies are the United Nations Development Programme (UNDP), the United Nations Industrial Development Organization

[10] Secretariat of the Basel, Rotterdam and Stockholm Conventions, 2014a
[11] Tonnes reported as kilogramme or vice versa
[12] Secretariat of the Basel, Rotterdam and Stockholm Conventions, 2014a
[13] *Ibid.*, 2014b
[14] *Ibid*., 2009, 2010, 2011
[15] Waste electrical and electronic assemblies or scrap containing components such as accumulators and other batteries included on list A, mercury-switches, glass from cathode-ray tubes and other activated glass and PCB-capacitors, or contaminated with Annex I constituents (*e.g.*, cadmium, mercury, lead, polychlorinated biphenyl) to an extent that they possess any of the characteristics contained in Annex III (note the related entry on list B B1110).
[16] Waste metal cables coated or insulated with plastics containing or contaminated with coal tar, PCB 11, lead, cadmium, other organohalogen compounds or other Annex I constituents to an extent that they exhibit Annex III characteristics.
[17] Wastes, substances and articles containing, consisting of or contaminated with polychlorinated biphenyl (PCB), poly-chlorinated terphenyl (PCT), polychlorinated naphthalene (PCN) or polybrominated biphenyl (PBB), or any other polybrominated analogues of these compounds.

(UNIDO), the World Bank and United Nations Environment Programme. The GEF website currently lists 46 projects targeting PCB; However, there may be additional projects on chemicals management that include PCB[18]. Most of these are currently under implementation. For the purpose of this report, data have been extracted from documents such as project identification forms (PIFs) and, where available, mid-term and/or final evaluation reports[19].

- The United Nations Commodity Trade Statistics Database (UN Comtrade)[20]: UN Comtrade collects standardized official annual trade statistics reported by countries. While concerned with merchandise trade, the statistics also cover the category 'waste oils containing polychlorinated biphenyls (PCBs)/polychlorinated terphenyls (PCTs)/polybrominated biphenyls (PBBs)'[21].
- A survey: The Secretariat and UNEP Chemicals Branch conducted a survey for the purpose of gathering additional, up-to-date information on the amounts of PCB (a) eliminated within national boundaries, (b) exported for elimination, (c) imported for elimination, (d) stored safely awaiting elimination, and (e) still available/in use or in need of safe storage/elimination. While the primary aim was to collect data from GEF implementing agencies on completed and ongoing GEF projects, the reporting template (see Annex A) was also sent to the members of the advisory committee of the PEN, the UNEP Regional Offices, and the Basel and Stockholm Convention Regional Centres.

In addition, information from technical reports and other sources was consulted, including

- Peer-reviewed articles published in scientific journals
- The global[22] and regional reports of UNEP's Regionally Based Assessment of Persistent Toxic Substances[23]
- The Basel Convention Regional Centre for Francophone Africa's (BCRC-AF) 'consolidated inventory report' of the project on 'demonstration of a regional approach to environmentally sound management of PCB liquid wastes and transformers and capacitors containing PCB'[24]
- Regional workshops organized under the umbrella of the Stockholm Convention[25]
- Information available through regional economic integration organizations, such as the European Union (EU) (*e.g.*, the Chemical Legislation European Enforcement Network's (CLEEN) 'EuroPCB: inventory PCB enforcement in member states'[26] or North American Free Trade Agreement's (NAFTA) (*e.g.*, the 'PCB Implementation Task Force Final Evaluation Report on the North American Regional Action Plan on PCBs'[27])

2.2. Terminology and classifications

The Stockholm Convention requests parties to identify, label and remove from use equipment containing greater than 0.05 % PCB and volumes greater than 5 litres as well equipment containing greater than 0.005 % PCB and volumes greater than 0.05 litres (Annex A, part II, paragraph (a))[28]. In line with this approach, existing stockpiles and the amounts eliminated reported in this document refer to equipment containing greater than 0.005 % and volumes greater than 0.05 litres, unless otherwise specified.

[18] GEF, 2014. The project data base publicly available on the GEF's website has been searched using the query 'PCB'. It should be noted that there may be additional projects covering PCB inventories and/or disposal, notably those more generally targeted at the environmentally sound management of POPs. However, for this initial report, these have not been taken into account.
[19] Some project documents (*e.g*. mid-term or final evaluations) have been provided by the implementing agencies, others have been accessed on the website of the GEF (GEF, 2014).
[20] United Nations, 2014
[21] Code 271091
[22] UNEP, 2003
[23] *Ibid.*, 2002a, 2002b, 2002c, 2002d, 2002e, 2002f, 2002g, 2002h, 2002i, 2002j, 2002k, 2002l
[24] Basel Convention Regional Centre for French-speaking countries in Africa in Senegal, 2007
[25] Secretariat of the Basel, Rotterdam and Stockholm Conventions, 2014c
[26] Chemical Legislation European Enforcement Network, 2005a, 2005b
[27] CEC, 2006
[28] UNEP, 2001

Many countries classify equipment containing greater than 0.05% PCB as equipment manufactured with PCB[29] and equipment containing between 0.005% and 0.05% PCB as equipment contaminated with PCB[30]. This distinction is also used in the present report. Some countries distinguish between scheduled and non-scheduled[31] or high- and low-density PCB[32], respectively. Some countries refer to equipment with a PCB content between 0.0002% and 0.005% as equipment with 'residual PCB'[33]. Equipment containing less than 0.0005% is often considered 'PCB-free'[34]. Alternatively, many countries set the threshold at 0.0002%[35]. The term 'PCB-assumed' is mostly used to refer to liquids and equipment that is considered as containing greater than 0.005% PCB until further laboratory analysis can specify the PCB content[36] (test kits used for initial screening do not provide conclusive results and are only the first stage in determining PCB content[37]).

In line with the mandate received by the COP to the Stockholm Convention, this report uses the term 'elimination'. Meanwhile, the Stockholm Convention requests the 'environmentally sound management' by 2028. 'Elimination' is here understood as referring to 'environmentally sound disposal' as defined in the Basel Convention's general technical guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with POPs[38]. It thus encompasses the destruction, irreversible transformation or use of other disposal methods when neither destruction nor irreversible transformation is the environmentally preferable option (such as permanent storage in underground mines) or when the POP content is low. Such operations may or may not be preceded by pre-treatment operations. In many instances, decontamination is sufficient. A number of methods are commercially available for this purpose and are listed in the technical guidelines. It follows, that other elements of environmentally sound management, such as storage, are not sufficient to fall under the category of 'elimination'.

2.3. Data Collection and Evaluation

In a systematic approach, first, UNEP Chemicals and Waste Branch set-up several tables (MsExcel format) listing the countries by regional groups and organized the variables of interest in columns for each country: Therein, one worksheet lists the amounts of PCB still in need of elimination, including the year to which the data apply (*e.g.* the year in which a number of transformers were incinerated or the year in which the specified amount of capacitors were in use), type of waste/material/equipment, number of units, solid mass, liquid mass, total mass, PCB content, status in life-cycle, year in which the information was provided, and the specific source of information. Where necessary, comments were added providing further relevant information or clarifying assumptions that had been made in gathering the data (*e.g*. conversions or extrapolations). In a second worksheet, the amounts of PCB already eliminated were summarized; columns additional to those listed above featured the disposal operation (*e.g.*, high-temperature incineration or alkali-metal reduction), whether the waste was domestically disposed, imported or exported, the trading partner, where applicable, and the status, *i.e.* if elimination was complete or scheduled to take place in the near future.[39]

Second, the table was populated with data from the sources listed in section 2.1. The data were sorted on three levels: first the country, second the source of information and third the year to which the information applied. In many instances, adjustments, assumptions and/or extrapolations had to be made to insert the data in the respective columns of interest, including the following:

[29] Sometimes also referred to as 'pure PCB'.
[30] See for example: Ecuador, 2006, p. 45
[31] See for example: Commonwealth of Australia, 2006, p. 35
[32] See for example: People's Republic of China, 2007, p. 76
[33] See for example: Mexico Distrito Federal, 2007, p. 93
[34] See for example: Republique de Madagascar, 2008, p. 41
[35] See for example: Ministry of Environment and Forests Bangladesh, 2007, p. 101
[36] See for example: Ministry of Environment, Forestry and Water Administration of Albania, 2006, p. 13
[37] UNEP Chemicals and Waste Branch, 2002, p. 20
[38] Basel Convention, no date
[39] The full data set will be published on the website of the Secretariat of the Basel, Rotterdam and Stockholm Conventions (BRS Secretariat).

- Where no information was given on the PCB content of the liquid or equipment in question, but it was reported as PCB liquid or equipment, it was assumed to contain/be contaminated with PCB at concentrations greater than 0.005%[40]. Where it was clearly stated that the inventory in question simply listed all equipment inventoried in the country, irrespective of PCB suspicion, the data were not included. By contrast, where the liquid or equipment was suspected to contain/be contaminated with PCB, the data were included.
- If specification on the volume was lacking, it was assumed to be greater than 0.05 litres.
- While information on the PCB content is often available, the volume is specified in very few instances. For the purpose of this report, it is therefore assumed that where the liquid or equipment is reported as containing or contaminated with PCB, it also containing volumes greater than 0.05 litres.
- Where expert judgment suggested that a quantity was reported using the wrong unit of measurement (*e.g.* as kilogram instead of tonne) or separator (*i.e.* using a comma for decimal marks or a dot as thousands separator), it was adjusted accordingly.
- Some countries report liquid in volume (*e.g.*, litres), rather than mass (*e.g.*, tonnes). In order to include such data in the statistical evaluation, it was necessary to convert these volumes into mass. In line with existing guidance material[41], a density of 1.5 kg/L PCB dielectric is assumed [42]. It should be noted that the density may in fact often be much lower due to a dilution of the oil; however, it is considered more desirable to over- rather than to underestimate the amounts of PCB still to be eliminated.
- Another harmonization included the conversion of short tons to metric tons.
- If a range of values was given, the middle point was taken to allow for statistical analysis, specifying the whole range in the comments cell.
- Where an estimate of the total amount of equipment typically containing or contaminated with PCB and an estimation of the share was given based on sample analysis, extrapolations were made. This was only done where the sample size was considered sufficiently high and representative of the national situation. A number of preliminary inventories estimate the total amounts of liquids and equipment typically containing or contaminated with PCB, such as transformers or capacitors, in the country, without an estimation of the share actually containing or contaminated with PCB. In such cases, the relevant figures have not been included as they would disproportionately skew the overall results.
- Whenever a total mass eliminated was reported for an interval (*i.e.* z tonnes over the period of year x until year y), it was distributed evenly across the years. Where no date was given, it was assumed that the elimination/export/import took place in the year before the reporting.
- In order to allow for statistical analysis, the numerous categories reported by countries were simplified to fit in the following categories: 'Transformers', 'capacitors', 'transformers and capacitors', 'equipment', 'oil', 'drums', 'open applications', 'others', and 'unspecified'. It should be noted that some of these categories include a variety of material with varying characteristics. For example, the category 'equipment' may include circuit breakers, switches, lighting ballasts and transformers. The diversity may be even larger for the categories 'others' (including for instance soil, parts from shipwrecks, or waste cloths) and 'unspecified'.

Third, the gathered data were ‘cleaned’ by examining each row and cell individually. Extreme outliers were subjected to special scrutiny and, in case of doubt regarding the accuracy of the data, the relevant focal points of the country in question were contacted for clarification. Moreover, the data were

[40] During the preparation of inventories, it is often assumed that non-labeled equipment was manufactured with PCB, equipment containing a producer label not mentioning the PCB content is suspected to be contaminated with PCB and that equipment having a green ‘PCB-free’ label is free of PCB (UNEP Chemicals and Waste Branch, 2002, p. 9, p. 13; *ibid*., 2013, pp. 29-31; UNEP, no date, p. iv)

[41] Secretariat of the Basel Convention, 2003

[42] This is in line with the Secretariat of the Basel Convention’s Training Manual on the ‘Preparation of a National Environmentally Sound Management Plan for PCBs and PCB-Contaminated Equipment (Secretariat of the Basel Convention, 2003)

interpreted in the light of further information available from alternatives sources. The data was then either adjusted or removed from the set with a corresponding note in the comments.

Since multiple sources have been used to gather data, there is a potential risk of 'double counting', *i.e.* different sources reporting the same amounts. To avoid this, efforts were made for each country (as well as across countries, in the case of trade data), to remove from the set any amounts that can be considered as already covered by another source according to best judgment. This exercise was complicated by the fact that the same data were often reported in different formats (for example, one source lists a certain number of transformers without specifying the mass, while another source only reports the mass).

In deciding which data to include/exclude, the following criteria were applied: As a default, where available and if considered solid according to expert judgment, data from the national reports were treated favourably in a 'hierarchy of sources'. NIPs (in most, but not all cases providing the same data as national reports) were second. More recent data from other sources were used to verify and, where considered necessary, adjust as well as to fill potential gaps. In a number of cases, data from national reporting were so incomplete and/or obviously inaccurate as to warrant using other sources. Information from alternative sources was also used if it was considerably more recent and comprehensive.

Lastly, the total mass of PCB was calculated from all reported units. In doing so, difficulties were encountered as the total mass is often not reported. Many countries report a few or only one of the relevant variables (*e.g.*, only the number of capacitors or the liquid mass is given). Where the total mass was not specified, the following steps were taken in order to arrive at an estimate for the total mass: Average ratios were calculated between the total mass and the respective other variables where these were reported in conjunction. Both for the mass still in need of elimination and for the mass already eliminated, this was done for each of the main categories identified (transformers, capacitors, *etc*.). The thus obtained ratios were then applied as conversion factors to obtain estimates of the total mass based on other reported variables. The various figures thus obtained were then summed and added to the total mass already reported, thus yielding overall estimates of the total mass already eliminated as well as the total mass still in need of elimination. This is explained in more detail below.

2.4. Challenges and Limitations

In compiling the data presented in this report, a number of challenges were encountered, resulting in some important limitations as regards the statistical analysis and the corresponding conclusions that could be drawn. These limitations essentially relate to the quality of national inventories:

- For 14 countries, no quantitative data on the mass to be eliminated were available (four from Africa, seven from Asia-Pacific, two from GRULAC and one from CEE)[43]. For 53 countries no quantitative data on the mass already eliminated were available (29 from Africa, 14 from Asia-Pacific, 7 from GRULAC and 3 from CEE)[44].
- Non-Parties with substantial historic production or consumption of PCB and elimination capacities, notably the USA and Italy, were included in the assessment to the extent possible[45]. Given the absence of national reports and national implementation plans submitted under the Stockholm Convention, data were gathered via personal communications with the relevant authorities and desk studies.

[43] Africa: Angola, Libya, Mozambique, Namibia; Asia-Pacific: Bahrain, Kuwait, Maldives, Myanmar, Micronesia, United Arab Emirates, Yemen; CEE: Bosnia and Herzegovina; GRULAC: Saint Kitts and Nevis, Saint Vincent and the Grenadines

[44] Africa: Angola, Belize, Benin, Botswana, Burkina Faso, Burundi, Cape Verde, Central African Republic, Chad, Comoros, Djibouti, Egypt, Ethiopia, Gambia, Lesotho, Liberia, Libya, Malawi, Mali, Mauritania, Namibia, Niger, Sao Tome and Principe, Sierra Leone, Sudan, Swaziland, Tanzania, Togo, Uganda; Asia: Cambodia, Democratic People's Republic of Korea, Kuwait, Lebanon, Maldives, Myanmar, Niue, Oman, Pakistan , Papua New Guinea, Qatar, Syria, Tajikistan, United Arab Emirates; Eastern Europe: Albania, Armenia, Georgia; GRULAC: Bahamas, Barbados, Bolivia, Cuba, Guyana, Nicaragua, Paraguay

[45] Quantitative data was available for the following non-parties: Andorra, Israel, Italy, Malta, USA, Uzbekistan

- To date, the large majority of countries developed preliminary inventories only. These are typically very limited in scope as regards coverage of the types of equipment (*e.g.* only covering transformers and capacitors), sectors (in many cases limited to the public electricity network) and geography (in many cases only urban areas and certain provinces are taken into account). A substantial share of inventories relied on the use of preliminary screening tools, lacking subsequent chromatographic verification.
- Data on the amounts of PCB in open applications are very scarce and limited to very few developed countries. It shall be noted that Part II of Annex A of the Stockholm Convention calls upon Parties to identify other articles containing more than 0.005 % PCB (*e.g.*, cable-sheaths, cured caulk and painted objects) and manage them in a sound manner.
- This report does not address PCB-contaminated sites and PCB currently landfilled. Only very few data are available; however it is probable that there are very large amounts of soil contaminated with PCB as well as PCB liquids and equipment landfilled.
- Most inventories rely on very rough estimates, sometimes based on incomplete data and/or analysis of small sample sizes.
- The practice of retro-filling transformers that had originally been manufactured with PCB with mineral oil is widespread, with the result that the newly introduced oil may become contaminated with PCB. It is very difficult to estimate the amounts of oil thus contaminated and little data are available.
- Optimally, information is available on all PCB-suspect types and materials including the respective number of units, solid mass (*e.g.*, of drained but contaminated transformers), liquid mass (*e.g*. of the transformer oil), total mass, and PCB content. However, countries typically just report a few or only one of these variables. For instance while one country may report the number of transformers, another may only report the estimated total mass of dielectric oil. This limitation does not only apply to developing countries and economies in transition but also to many developed countries. Important technical limitations exist in this respect; for example, it may be difficult for many countries to report average PCB content in a group of contaminated oil, absent the necessary laboratory capacity.
- The data are often insufficient to assess a development and identify trends regarding the amounts of PCB in use, out of service and eliminated over time. In theory, inventories conducted at different points in time could be used to assess the amounts of PCB eliminated within that period. In practice, however, such data cannot be used to make precise estimates, for instance because newly identified stocks might have been added in the meantime. Thus, it is not unusual to see the amounts reported in inventories increase over time. The national reports for example do not provide any clarifications in this respect.
- Due to a lack of consistency, including within individual reports, it is often very difficult to assess how decimal marks and thousands separators are used. The units are sometimes not clearly indicated. Another difficulty related to the fact that in many instances countries report that PCB waste has been imported/exported without specifying the country of origin/destination. Despite available guidance materials, inventories are not harmonized in structure and detail of information. Instead of relying on a standardized approach, different methodologies are followed in conducting inventories. For example, some are based on voluntary registration, others on regulatory enforcement, and yet others on questionnaires. Methods include for instance sampling, extrapolation, site visits, *etc*.
- As previously noted, several issues need to be highlighted with regard to the classification into the nine categories noted above: The category ‘equipment’ may in fact include transformers and capacitors; however, the different types are often subsumed under this category. Moreover, the categories ‘others’ and 'unspecified' are extremely diverse, meaning that any generalizations about these categories have to be interpreted with caution.

Due to these shortcomings, assessments that were carried out on the ground following preliminary inventories have often revealed that the actual situation is dramatically different. It was beyond the scope of this initial assessment to try to fill the gaps prevalent in the available data. As a follow-up activity, it

could therefore be recommended to carry out additional country-specific research where no quantitative data are available (thereby considering factors such as the country's electricity production and drawing comparisons with countries having similar economic characteristics) and to address the issue of open applications.

An alternative to using national inventories is to follow a mass balance approach. This means taking the total amount of PCB produced as a baseline to estimate how much liquids and equipment containing PCB has been in use and thus to arrive at an assessment of the mass still in need of elimination. However, this is difficult because data on the production of liquids and equipment containing PCB are incomplete. Moreover, it is furthermore important to note that due to dilution and cross-contamination, the mass of liquids and equipment containing or contaminated with PCB are necessarily much larger than the amounts of PCB produced: A single tonne of PCB can generate multiple tonnes of PCB wastes. For example, the practice of retro-filling transformers that had originally been manufactured with PCB with mineral oil is widespread[46], with the result that the newly introduced oil may become contaminated with PCB. It is very difficult to estimate the amounts of oil and containers/casings thus contaminated.

Furthermore, large amounts of PCB have been released to the environment (*e.g.*, due to leakage of transformers or bad practices such as open burning of PCB wastes) and can thus not be subject to 'elimination' in the sense that equipment can. Unknown amounts may have been stolen and/or disposed illegally. A lot of PCB might have gotten 'lost', *e.g.*, due to a lack of documentation and poor labelling. In some cases, this may have implications for the implementation of GEF-funded and other projects, as baselines may change between the undertaking of inventories and execution of the activities.

[46] See for example *ibid.*

3. Results

3.1. Total production of PCB

The starting point for an assessment of progress towards eliminating PCB is to know how much PCB has been produced. From multiple sources the total amount of PCB produced is estimated between 1 and 1.6 million tonnes (see Table 1), which is in agreement with earlier reports[47]. Production has been limited to a small number of countries (12) and companies (17). Commercial production started around 1929-1930 and has progressively been phased out in the second half of the century. This figure includes the USA and Italy, both of which are not Parties to the Stockholm Convention. Removing these gives an estimate of 0.5 to 0.8 million tonnes.

Most sources suggest that production ended in 1993. However, according to its NIP, the Democratic People's Republic of Korea (DPRK) continued producing PCB at least until 2006[48]. Information received during the fifth meeting of the advisory committee of the PCB Elimination Network (PEN) suggests that production in the DPRK is ongoing. This was confirmed during the the 'Expert Meeting on the Effectiveness Evaluation of Implementation of the Stockholm Convention for PCB' as well as the 'Sixth Meeting of the Advisory Committee of the PEN'.

While few countries produced PCB, a number of countries imported PCB to produce transformers and capacitors or other liquids and equipment[49]. However, comprehensive data on the total amounts of liquids and equipment manufactured with PCB are lacking. Information on historical consumption is scarce. In most cases, it is difficult to get data on historical imports and exports; even in the Western Europe and Others Group (WEOG). It has been estimated that 48 % of the PCB production used for transformer oil, 21 % for small capacitors, 10 % for other closed systems; 21 % open uses[50]. Thus, transformers usually represent the single largest source of PCB[51]. More generally, electrical equipment can be considered as the main destination for PCB.

[47] For example at 1 million t (UNEP 2002c); more than 1 million t (UNEP, 2002g; WHO, 1992); 1.2 million t (Holoubek, 2000); 1,3 million t (Breivik et al., 2007); 1,5 million t (Ivanov and Sandell, 1992; Rantanen, 1992
[48] Democratic People's Republic of Korea, 2008
[49] UNEP Chemicals, 2004
[50] Urs Wagner in the PEN Magazine (Secretariat of the Stockholm Convention, 2010)
[51] Also see for example UNEP, 2002j

Table 1: Overview of estimated total production of PCB[52]

Country	Start of production		End of production		Amount (1,000 t)		Sources
	Earliest estimate	Latest estimate	Earliest estimate	Latest estimate	Lowest estimate	Highest estimate	
Korea (DPR)	1960s	1960s	2006	>2006[53]	25	30	Democratic People's Republic of Korea, 2008
Soviet Union/Russian Federation	1938	1939	1993	1993	180	180	AMAP, 2000; GEF, 2012; Ministry of Environment and Water of Bulgaria, 2012; UNEP, 2002g
Spain	1930	1955	1984	1986	25	29	Bletchly as cited in WHO, 1993; de Voogt and Brinkman (1989) in Breivik *et al*. 2007; Ministerio de Medio Ambiente y Medio Rural y Marino of Spain, 2004; OECD as cited in Holoubek, 2001
Czechoslovakia	1959	1959	1984	1984	21	21	OECD as cited in Holoubek, 2001; Schlosserova in Breivik *et al*., 2007; Slovak Environmental Agency, 2006
West Germany	1930	1950	1983	1983	59	300	Bletchly as cited in WHO, 1993; de Voogt and Brinkman as cited in Breivik *et al*., 2007; Federal Ministry for the Environment and Nature Conservation of Germany, 2010; OECD as cited in Holoubek, 2001
Italy[54]	1958	1958	1983	1983	24	31	Bletchly as cited in WHO, 1993; de Voogt and Brinkman as cited in Breivik *et al*., 2007; OECD as cited in Holoubek, 2001
France	1930	1930	1980	1984	102	135	Bletchly as cited in WHO, 1993; de Voogt and Brinkman as cited in Breivik *et al*., 2007.; Ministère des Affaires Etrangères of France, 2004 ; OECD as cited in Holoubek, 2001
Poland	1966	1966	1977	1977	2	2	Faladysz and Zulkovski *et al*. as cited in Breivik *et al*., 2007
USA[55]	1929	1930	1975	1977	476	700	Bletchly as cited in WHO, 1993; Canadian Council of Resource and Environmental Ministers as cited in Holoubek, 2001; de Voogt and Brinkman as cited in Breivik *et al*., 2007; Holoubek, 2001; OECD as cited in Holoubek, 2001 ; UNEP, 2002b; CEC, 1996
China	1960	1965	1974	1983	7	10	Jiang *et al*. as cited in Breivik *et al*., 2007; Li as cited in UNEP, 2002g; Ministry of Environmental Protection of China, 2007; People's Republic of China, 2007; Wong, 1999 as cited in Fiedler, 2001; World Bank, 2005
Japan	1952	1954	1972	1972	59	59	Bletchly as cited in WHO, 1993; Breivik *et al*.; Ministry of Foreign Affairs of Japan, 2010; Hiraoko as cited in 2002g; OECD as cited in Holoubek, 2001
UK	1951	1954	1965	1977	66	67	Bletchly as cited in WHO, 1993; Breivik *et al*.; Department of Environment, Food and Rural Affairs of the United Kingdom, 2007, 2010; OECD as cited in Holoubek, 2001
Total					**1,046**	**1,512**	

[52] Sorted by the earliest estimate of the end of production

[53] Information received during the fifth meeting of the Advisory Committee of the PEN, held on 26-27 November 2014 in Geneva, Switzerland, suggests that production in the DPRK is ongoing. This information was verified during the joint 'Expert Meeting on the Effectiveness Evaluation of Implementation of the Stockholm Convention for PCB and Sixth Meeting of the Advisory of the PCB Elimination Network (PEN)', held on 14-16 December, 2015, in Brno, Czech Republic. The meeting report will soon be made available.

[54] Not a party to the Stockholm Convention

[55] Not a party to the Stockholm Convention

3.2. Amounts Eliminated to Date

3.2.1. Amounts Eliminated According to the National Reports

As outlined in the mandate, this evaluation has to be based on the third national reports on progress in eliminating PCB submitted by Parties. The total mass of liquids and equipment containing or contaminated with PCB at concentrations greater than 0.005 % eliminated according to the data provided in the first, second and third national reports[56] amounts to *ca*. 628 thousand tonnes. However, there is significant double counting; for example, substantial shares of the amounts reported in the second and third national report may already have been reported in the first. It was beyond the scope of this assessment to eliminate such double counting. Figure 1 illustrates how much has been reported as eliminated in each of the respective national reporting cycles.

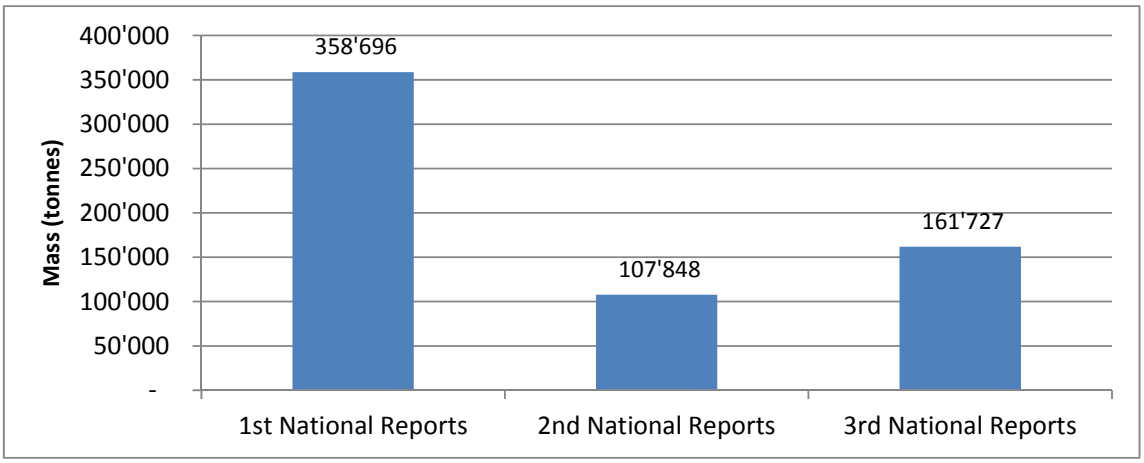

Figure 1: Total mass of PCB eliminated as reported in the first, second and third national reports under the Stockholm Convention[57]

As can be seen, the largest mass was reported as eliminated in the third national reports, at ca. 96 thousand tonnes. The mass reported in the first round amounts to ca. 48 thousand tonnes and in the second round to only *ca.* 27 thousand tonnes. It should be noted that efforts have been undertaken for the purpose of this report to avoid double-counting values. A lot of the data reported in the second and third national reports have already been reported in the first report. Thus, in many, but not all cases, the mass quoted for the second and third national reports only represents what has been eliminated in the preceding five-year period. In some cases, updated data were available for the periods already covered by the preceding report(s).

Little significance should be attached to the total numbers quoted here, given their non-comprehensive character (also see section 2.4). However, it may be possible to identify a trend: The mass of PCB eliminated within the period covered by the third national reports is significantly higher than the mass for the period covered by the second national reports, although the number of reports submitted to date is much lower. This increase may be interpreted as an indication that progress is being made towards accelerating the elimination of PCB. An alternative explanation is that reporting improved.

3.2.2. Amounts Eliminated According to All Sources of Information

As noted, the data available in the national reports provide only limited insights into the question of how much progress has been made towards eliminating PCB. It is therefore necessary to include the additional sources cited in section 2.1.

[56] Secretariat of the Basel, Rotterdam and Stockholm Conventions, 2014a
[57] Data gathered from *ibid*.

Data on the elimination of PCB liquids and equipment are reported in three different formats: In units, total mass and/or oil equivalent. Most countries report the total mass, possibly together with the number of units (where applicable) and the corresponding mass of oil contained in the liquids or equipment. However, as outlined above, in a number of instances only the units and/or the oil equivalent have been reported. Table 2 shows the amounts reported in the various configurations, with 'n.a.' indicating where no data are available.

Table 2: Reported number of units, total mass and oil of eliminated PCB liquids and equipment (all values rounded)[58]

Row	Data available	Units (#)	Total mass (t)	Oil (t)
1	Units, mass and oil	25,332	46,737	14,243
2	Units and mass	50,611	16,558	
3	Mass and oil		2,168	19,621
4	Units and oil	7,163	?	8,736
5	Units	1,528,458	?	
6	Mass		1,269,092	
7	Oil		?	722
Total			**?**	

The variable of concern for the purpose of this assessment is the total mass of liquids and equipment containing or contaminated with PCB that has been eliminated. While also of interest, we will not be concerned with estimating the missing number of units (row 3) and mass of oil (row 2).

In order to be able to fill the cells marked in red, the following steps were taken: First, the average ratio between the number of units and the total mass was calculated based on all instances where both variables were reported in conjunction. This was done for each of the nine categories listed above (transformers, capacitors *etc*.), thus yielding nine conversion factors (see Table 3). For example, the ratio to convert units in the category 'transformers' is 5.276, so on average, every transformer has a reported mass of 5.276 tonnes. These factors were then used to estimate a value for the total mass in rows 5 (i.e. the cases where only the number of units was reported).

Table 3: Conversion factors to convert units to total mass (note: all values rounded)[59]

Type	Units (#)	Mass (t)	Ratio
Transformers	2,882	15,205	5.276
Capacitors	30,590	2,067	0.068
Transformers and capacitors	24,338	46,107	1.894
Equipment	996	595	0.597
Oil	-	-	n.a.
Drums	649	128	0.197
Open applications	-	-	n.a.
Others	27	1,000	37.037
Unspecified	157	89	0.568

Expert judgement, some of the ratios presented above are at least questionable[60]. In particular, the ratio for transformers is much higher than what would have been expected. This is an indication that the

[58] Calculated based on Secretariat of the Basel, Rotterdam and Stockholm Conventions, 2014a, 2014b; Secretariat of the Basel, Rotterdam and Stockholm Conventions, 2009, 2010, 2011; GEF, 2014; UN, 2014; UNEP, 2003; UNEP, 2002a, 2002b, 2002c, 2002d, 2002e, 2002f, 2002g, 2002h, 2002i, 2002j, 2002k, 2002l; Basel Convention Regional Centre for French-speaking countries in Africa in Senegal, 2007; Secretariat of the Basel, Rotterdam and Stockholm Conventions, 2014c; Chemical Legislation European Enforcement Network, 2005a, 2005b; CEC, 2006; UNEP Chemicals and Waste Branch, 2014

[59] *Ibid*.

reported data are not accurate. Meanwhile, it is reasonable to assume that priority was given to the identification and elimination of the largest transformers. The ratio for capacitors is considered more realistic. As regards the other categories, it is difficult to provide an assessment, given their diverse composition (especially for the categories 'others' and 'unspecified').

Second, the average ratios between the mass of oil and the total mass was calculated based on all instances where both variables were reported in conjunction. Again, this was done for each of the nine categories (see Table 4). For example, the average ration between oil and mass for the same category is 1.727, so on average a tonne of oil reported in this category is equivalent to 1.727 tonnes of total transformer mass (i.e. the sum of solid and liquid parts. These factors were then used to provide an estimate for the total mass in row 7 (i.e. the cases where only the mass of oil was reported).

Table 4: Conversion factors to convert oil to total mass (note: all values rounded)[61]

Type	Oil (t)	Total mass (t)	Ratio
Transformers	147	254	1.727
Capacitors	3	32	9.545
Transformers and capacitors	13,925	45,858	3.293
Equipment	269	875	3.253
Oil	205	685	3.341
Drums	-	-	n.a.
Open applications	-	-	n.a.
Others	178	593	3.333
Unspecified	19,464	1,633	0.085

Third, the two sets of conversion factors (i.e. those to convert units to mass as well as those to convert oil to total mass) were used to estimate a range of possible values for row 4 (i.e. the cases where the number of units and the mass of oil were reported but not the total mass). Consequently, two estimates can be made for row 4: One is given by using the conversion factors on the number of units (as shown in Table 3), the other by using the conversion factors on the mass of oil (as shown in Table 4). Then, the mid-range was taken for the purpose of providing a single estimate of the total mass eliminated to date. Finally, the total masses were summed (see Table 5).

Table 5: Estimated total mass eliminated to date (note: all values rounded)[62]

Row	Data available	Units (#)	Total mass (t)	Oil (t)
1	Units, mass and oil	25,332	46,737	14,243
2	Units and mass	51,269	16,736	n.a.
3	Mass and oil	n.a.	2,168	19,621
4	Units and oil	7,163	between 3,677 and 53,575 or 28,626	151,739
5	Units	230,141	1,594,409	n.a.
6	Mass	n.a.	854,439	n.a.
7	Oil	n.a.	2,053	722
Total			between 2,934,693 and 2,984,593 **or 2,959,643**	

[60] This was also confirmed at the joint 'Expert Meeting on the Effectiveness Evaluation of Implementation of the Stockholm Convention for PCB and Sixth Meeting of the Advisory of the PCB Elimination Network (PEN)', held on 14-16 December, 2015, in Brno, Czech Republic. The meeting report will soon be made available.
[61] *Ibid*.
[62] *Ibid*.

The estimated total mass of liquids and equipment containing or contaminated with PCB at concentrations greater than 0.005% eliminated to date is thus estimated at ca. 3 million tonnes.

Some observations suggest that this estimate may be too high. While efforts were made to avoid any double counting of data from different sources, this possibility cannot be entirely excluded. This is especially due to the fact that in many instances countries report that PCB waste has been imported/exported without specifying the country of origin/destination. Interestingly, most of the data are only recorded from one of the trading partners, making it difficult to validate the provided data through a second source.

However, a number of arguments indicate that the estimate of 3 million tonnes is a strong underestimation. It can be assumed with almost absolute certainty that countries have not reported all amounts that have actually been eliminated. In many instances, countries noted that waste has been eliminated without giving any quantitative data. It can be reasonably assumed that a number of countries, especially in the WEOG, disposed large amounts of PCB, including before the entry into force of the Convention, without having provided quantitative data. For others, no information was available at all. The additional sources of information have not been sufficient to achieve a complete overview. For instance, trade data from the reporting under the Basel Convention were only available for the years between 2009 and 2013. The estimate is easily within the range of existing elimination capacity[63].

Examining the share of the various countries reveals that Japan accounts for ca. two thirds of the 3 million tonnes. Consequently, if Japan is removed from the data set, the amount eliminated to date shrinks to slightly less than 1 million tonnes. Two possible (though simplified) explanations exist: The first possibility is that Japan over-reported the amounts eliminated to date. A substantial amount reported by Japan is labelled as having concentrations below 0.5 %. A significant share of this may in fact have concentrations below the 0.005 % threshold, as the legal threshold in Japan is lower than that provided in the Stockholm Convention. Data taking the 0.005 % as threshold is not available. The second possibility is that the other countries under-reported the amounts eliminated to date. In fact, this is very likely, as pointed out in the previous paragraph. Moreover, Japan also reported large amounts above 0.5 %, unlike many other countries with similar industrial structures.

The data presented so far do not include the non-parties, most notably the USA and Italy. If these are included, the estimate increases to almost 11 million tonnes, which would imply that the non-Parties to the Convention, in particular the USA eliminated by far more PCB than the rest of the world combined. The more probable explanation, however, is that the data available for the USA in particular, were much more comprehensive that the data available for other countries.

Figure 2 breaks down the total mass eliminated by categories (non-Parties are not included). As can be seen, the category ‘equipment accounts for more than half, which was to be expected, given that it encompasses many categories, including in many cases transformers and capacitors. Among those that were clearly specified, transformers account for the largest share (ca. 5 %), followed by oil (ca. 4 %).

[63] See for instance UNEP Chemicals and Waste Branch, 2004

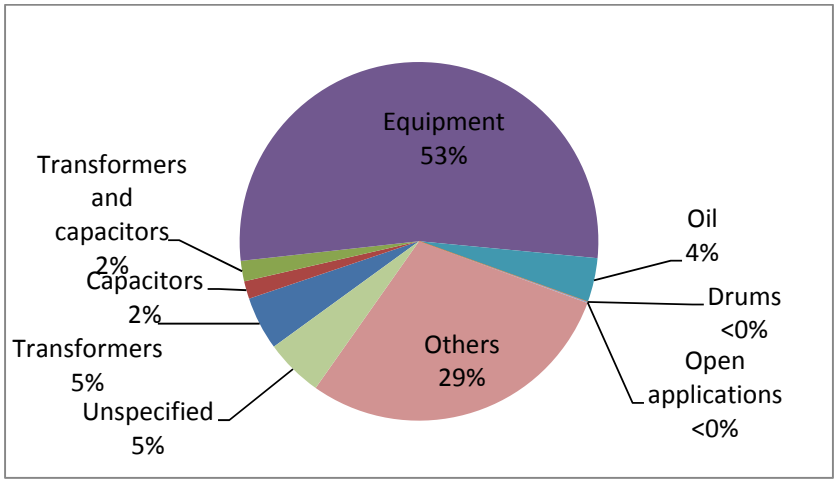

Figure 2: Share of total mass eliminated by categories[64]

3.2.3. Amounts Eliminated Between 1990 and 2015

Figure 3 shows the mass eliminated for each year between 1990 and 2015. Again, these data do not include non-Parties. Data provided for the years prior to this range were included under 1990. Available data suggest that there was a first boost in the amount of PCB eliminated per year in 1996 and then a second, much more pronounced boost in 2002. Elimination reached the highest level in 2011, followed by a rapid and then slow decrease until 2015.

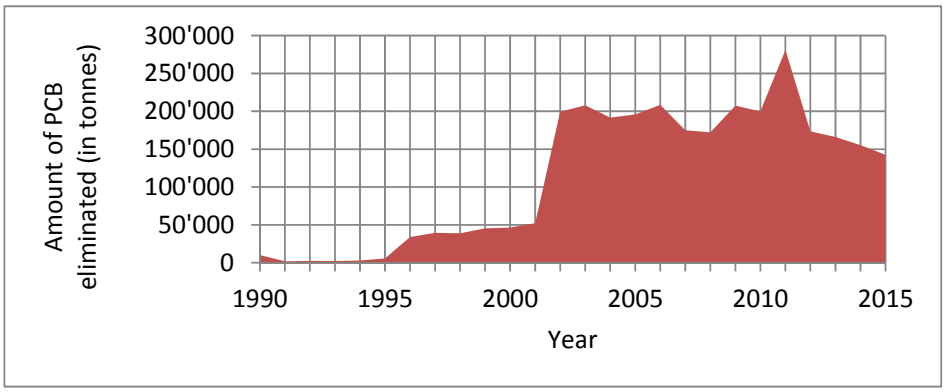

Figure 3: Mass eliminated by year[65]

Between 1990 and 2004, a total of ca. 880 thousand tonnes were reportedly eliminated. The total mass reported for the post 2004 period is much higher, namely 2.1 million tonnes. Thus, 70 % of the total was eliminated after the Convention's entry into force. Taking 2001 as the benchmark (negotiations on the text were concluded in 2000 and delegates adopted the Convention at the Conference of the Plenipotentiaries in May 2001), reveals that about 10 % were reportedly eliminated until 2001. It could be argued that the Convention's entry into force in 2001 marked a turned point and constituted a strong motivation for future Parties to scale up the elimination of PCB. However, the data should be viewed with

[64] Calculated based on Secretariat of the Basel, Rotterdam and Stockholm Conventions, 2014a, 2014b; Secretariat of the Basel, Rotterdam and Stockholm Conventions, 2009, 2010, 2011; GEF, 2014; UN, 2014; UNEP, 2003; UNEP, 2002a, 2002b, 2002c, 2002d, 2002e, 2002f, 2002g, 2002h, 2002i, 2002j, 2002k, 2002l; Basel Convention Regional Centre for French-speaking countries in Africa in Senegal, 2007; Secretariat of the Basel, Rotterdam and Stockholm Conventions, 2014c; Chemical Legislation European Enforcement Network, 2005a, 2005b; CEC, 2006; UNEP Chemicals and Waste Branch, 2014

[65] Calculated based on Secretariat of the Basel, Rotterdam and Stockholm Conventions, 2014a, 2014b; Secretariat of the Basel, Rotterdam and Stockholm Conventions, 2009, 2010, 2011; GEF, 2014; UN, 2014; UNEP, 2003; UNEP, 2002a, 2002b, 2002c, 2002d, 2002e, 2002f, 2002g, 2002h, 2002i, 2002j, 2002k, 2002l; Basel Convention Regional Centre for French-speaking countries in Africa in Senegal, 2007; Secretariat of the Basel, Rotterdam and Stockholm Conventions, 2014c; Chemical Legislation European Enforcement Network, 2005a, 2005b; CEC, 2006; UNEP Chemicals and Waste Branch, 2014

caution: Improved reporting in the years following the adoption of the text is possibly responsible: Indeed, many countries' national reports provide data from 2001 onwards.

The decreasing trend in the years after 2011 may be due to the fact that reporting for this period is still premature. This is especially true for the more recent years, in particular 2014 to 2015. (*e.g.* only 69 Parties submitted their third national reports, Basel Convention reporting data were not yet available for 2014 and 2015, *etc.*). It may also be the case that countries had already disposed the 'low-hanging fruits', *i.e.*, large obsolete stockpiles that were readily identified. Furthermore, it is conceivable that in some cases actual amounts turned out lower than expected, following chromatographic verification of preliminary screening results. Thus, several, partly contradicting trends may be at work.

3.2.4. Trade in Waste Oils Containing PCB According to UN Comtrade

What has been presented so far does not take into consideration the data available from UN Comtrade, according to which imports and exports of waste oils containing polychlorinated biphenyls (PCBs)/polychlorinated terphenyls (PCTs)/polybrominated biphenyls (PBBs) since 2002 (the first year for which data are available) amounted to 262,282 t and 228,168 t, respectively. The distributed across the years for imports and exports are shown in Figure 4 and Figure 5.

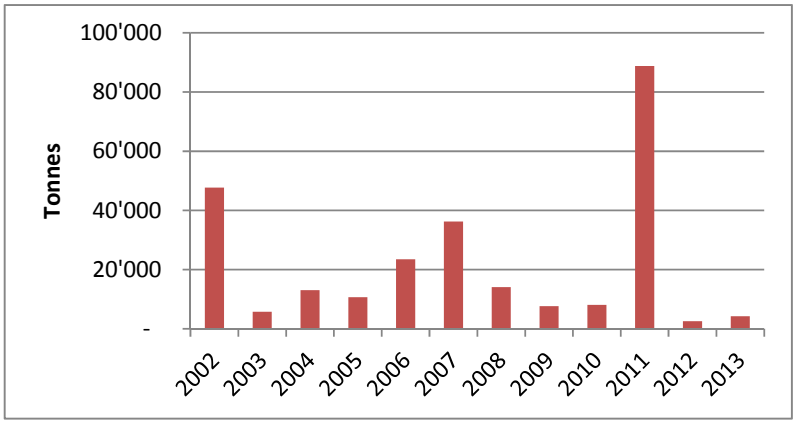

Figure 4: Imports of waste oils containing polychlorinated biphenyls (PCBs)/polychlorinated terphenyls (PCTs)/polybrominated biphenyls (PBBs) as reported under UN Comtrade[66]

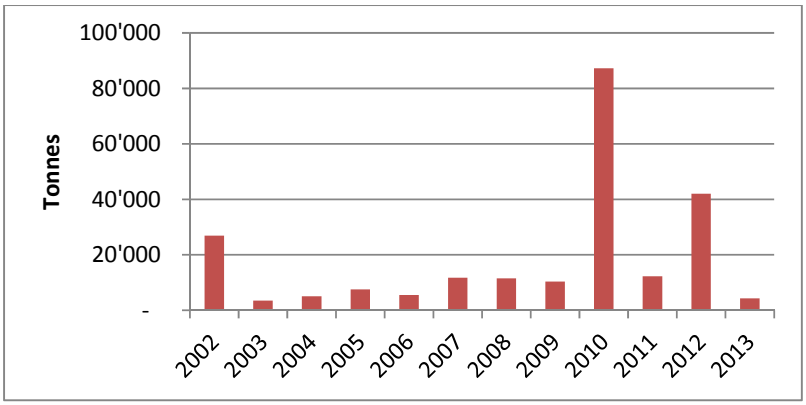

Figure 5: Exports of waste oils containing polychlorinated biphenyls (PCBs)/polychlorinated terphenyls (PCTs)/polybrominated biphenyls (PBBs) as reported under UN Comtrade[67]

It was not possible to include these data in the overall estimate since it is highly divergent from other data sets. It also contains some surprising results: For example: many developing countries report having

[66] United Nations, 2014
[67] *Ibid.*

imported waste oils containing PCB from developed countries. Country reporting of this category under UN Comtrade may therefore need to be clarified.

3.2.5. GEF Projects

As of January 2016, the GEF project database lists a total of 46 PCB projects[68] (42 national projects, of which six are completed, 18 under implementation, and 18 in the preparatory phase; three regional projects, of which two are under implementation and one is in the preparatory phase). Total funding allocated by the GEF for these projects amounts to *ca.* USD 171 million. Co-financing of *ca.* USD 459 million has been leveraged.

Information on the amounts of PCB (to be) eliminated under these projects has been gathered by UNEP Chemicals and Waste Branch and the Advisory Committee of the PCB Elimination Network. Quantitative data were available for 33 of these projects, with a total amount of GEF-grants at *ca*. USD 124 million and co-financing at *ca*. USD 323 million. Available data suggests that as part of these projects, *ca.* 23 thousand tonnes have been eliminated, while another 65 thousand tonnes are scheduled for elimination. Assuming that the total amount scheduled for elimination will be successfully eliminated, the cost per tonne of PCB waste eliminated would amount to *ca*. USD 1,385. Including co-financing raises the costs to *ca*. USD 4,992. It should be noted that these costs also include do not just include costs directly related to elimination (including transport *etc*.), but also other activities implemented as part of the projects, for example institutional strengthening or the establishment of a regulatory framework.

Elimination was among the objectives in four out of the six projects reported as completed. These four projects received GEF grants at a total of *ca*. USD 21 million and had co-financing amounting to about USD 17 million. In total, these projects reportedly eliminated 12,657 tonnes of liquids and equipment containing or contaminated with PCB. This is equivalent to a cost of *ca*. USD 1,675 per ton eliminated. If co-financing is included, the cost is at *ca*. USD 3,025 per ton eliminated. As above, it should be noted that these costs also include costs not directly related to elimination.

Considering the above figures in the light of commercial costs for handling and treatment of PCB suggests that GEF-funded projects have generally performed well in terms of cost-efficiency. Meanwhile, a more detailed assessment is necessary.

3.2.6. Regional Distribution

Figure 6: Origin of total mass eliminated by region shows how much mass has been eliminated from which region. Thus, exports from one region to another were counted for the exporting, rather than the import country/region, irrespective of which Party reported it.

[68] It should be noted that there also POPs projects with have PCB-related elements, but which were not included here.

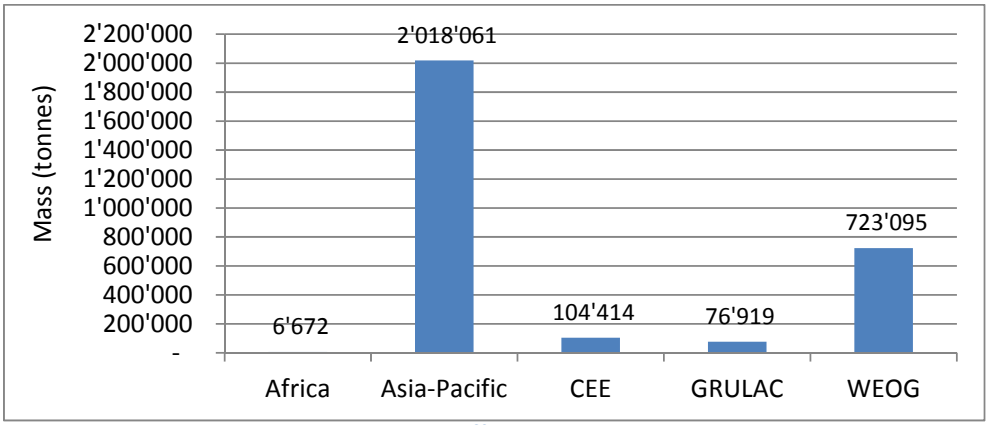

Figure 6: Origin of total mass eliminated by region[69]

As can be seen, by far the largest share of the total mass eliminated to date is from the Asia-Pacific Region at ca. 2 million tonnes, corresponding to ca. 68 % of the total. The WEOG follows with ca. 723 thousand tonnes (ca. 24 %). Relatively small amounts eliminated to date are from the others regions, namely ca. 104 thousand tonnes (ca. 4 %) from CEE, ca. 77 thousand tonnes (ca. 3 %) from GRULAC and ca. 7 thousand tonnes (less than 1 %) from Africa. As outlined above, Japan accounts for most of the large share of the Asia-Pacific region. Moreover, some of the figures presented here may be an underestimation.

As could be expected, the regions also followed different approaches in disposing of PCB wastes: For example, as shown in Figure 7: Elimination pathways in the WEOG, the Parties from the WEOG disposed 80 % of their PCB waste within the region. Ca. 16 % were exported for disposal outside the WEOG region (almost exclusively to the CEE region). It is safe to assume that the remaining 5 % for which no information was available was likely also eliminated within the region.

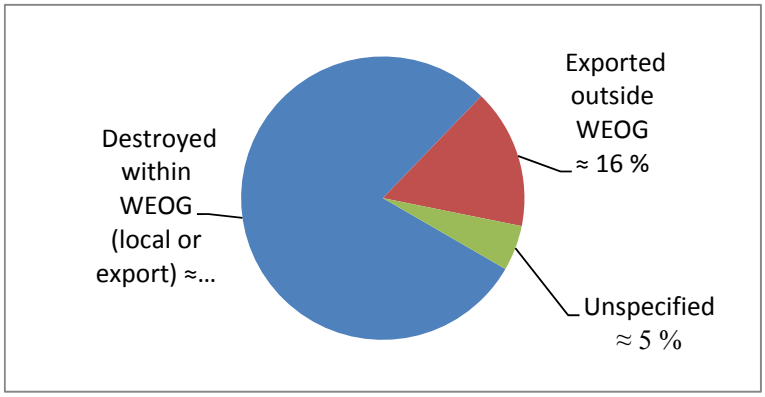

Figure 7: Elimination pathways in the WEOG[70]

The situation is even more extreme for the Asia-Pacific Region, which eliminated almost all of its PCB waste domestically. Very small amounts were exported/imported within the region and even smaller amounts were exported outside of the region.

By contrast, as shown in Figure 8, GRULAC exported almost 60 % of its PCB waste for elimination. Countries of destination were exclusively from the WEOG region. Notwithstanding, the GRULAC countries

[69] Calculated based on Secretariat of the Basel, Rotterdam and Stockholm Conventions, 2014a, 2014b; Secretariat of the Basel, Rotterdam and Stockholm Conventions, 2009, 2010, 2011; GEF, 2014; UN, 2014; UNEP, 2003; UNEP, 2002a, 2002b, 2002c, 2002d, 2002e, 2002f, 2002g, 2002h, 2002i, 2002j, 2002k, 2002l; Basel Convention Regional Centre for French-speaking countries in Africa in Senegal, 2007; Secretariat of the Basel, Rotterdam and Stockholm Conventions, 2014c; Chemical Legislation European Enforcement Network, 2005a, 2005b; CEC, 2006; UNEP Chemicals and Waste Branch, 2014

[70] *Ibid.*

also have some domestic capacity for disposal, with ca. 9 % eliminated within the region. No intra-GRULAC trading for disposal was reported. In about 32 % of the cases, no information was available.

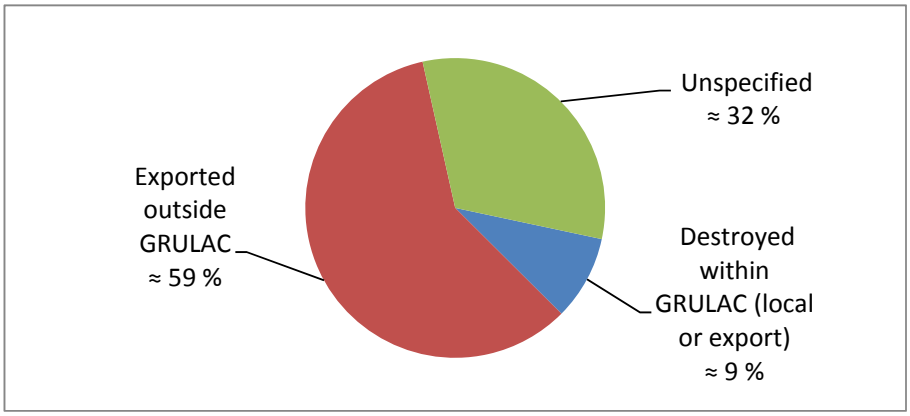

Figure 8: Elimination pathways in GRULAC[71]

The CEE Region reportedly eliminated 44 % of its waste within the region (see Figure 9). Around 17 % were exported to outside the region. A similar picture applies to Africa, which may be somewhat surprising given the limited capacity in the region.

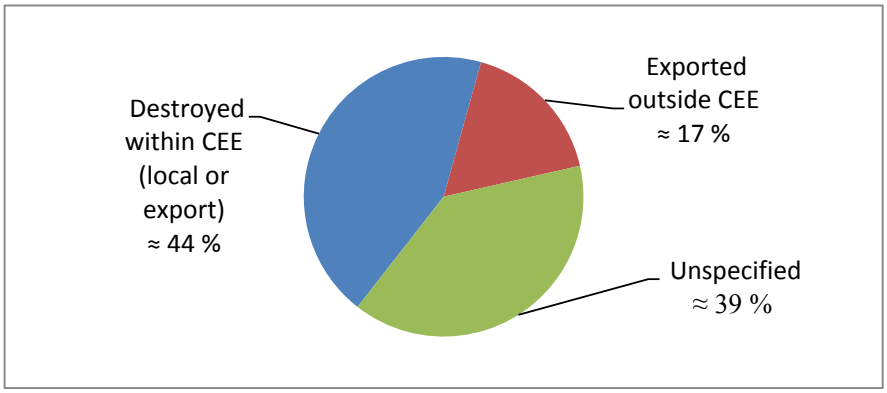

Figure 9: Elimination pathways in CEE[72]

3.2.7. Amounts Scheduled for Elimination

In addition to the amounts that have already been eliminated, to the extent possible, information was also gathered on the amounts with clear schedules for elimination. This includes for example stringent national schemes currently under implementation, such as that put in place by the Japanese government[73], GEF projects that are ongoing or in the preparatory phase, and instances where the waste has likely already been disposed of but was not yet reported accordingly as the source of information is outdated.

Using the same methodology explained above, the estimated total mass of liquids and equipment containing or contaminated with PCB at concentrations greater than 0.005 % scheduled for disposal (or already disposed but not yet confirmed) is thus estimated at ca. 75 thousand tonnes.

[71] *Ibid.*
[72] *Ibid.*
[73] A 'Law Concerning Special measures Against PCB Waste' was formulated in 2001 (Law No. 65) (JESCO, 2015).

3.3. Amounts Still to Be Eliminated

3.3.1. Amounts Still to be Eliminated According to All Sources of Information

The quantitative data on PCB in use, stockpiled or waste were organized in many different formats which slightly differ from those used for the amounts eliminated. These were classified in the following categories: number of units, total mass, solid mass, liquid mass, and PCB dielectric mass.

For some countries data are available for all of these categories, i.e. the units together with the relevant total mass, solid mass and information on the liquid, including its mass and whether it is 'pure' PCB, contaminated with PCB, or PCB-free. Meanwhile, as is the case for the mass already eliminated, most countries only report a few or only one of these variables, making it difficult to estimate the total mass that is still in need of elimination. Table 6 shows the values reported in the various configurations. Note that there is a distinction made for the liquid/oil. The column 'liquid mass' is applicable where there is no information on whether the liquid/oil contains/is contaminated with PCB or not. By contrast, the column 'PCB oil mass' lists the mass of liquid/oil which has been reported as containing/contaminated with PCB.

Table 6: Data reported on liquids and equipment containing or contaminated with PCB at concentrations greater than 0.005 % (note: all values rounded)[74]

Row	Data available	Units	Total mass (t)	Solid mass (t)	Liquid mass (t)	PCB dielectric (t)
1	Units, total mass, solid mass, liquid mass	335,774	168,402	122,385	44,897	n.a.
2	Units, total mass, solid mass, PCB dielectric mass	279,730	91,476	69,534	n.a.	22,511
3	Units, total mass, solid mass	21	29	29	n.a.	
4	Units, total mass	19,314	8,941	n.a.	n.a.	n.a.
5	Units, liquid mass	81,389	?		8,281	
6	Units, PCB dielectric mass	602,430	?			41,918
7	Units	8,371,460	?			
8	Total mass, solid mass, liquid mass	n.a.	65,171	17,948	15,042	
9	Total mass, solid mass, PCB dielectric mass	n.a.	318	187		131
10	Total mass, solid mass	n.a.	12,537	12,537		
11	Total mass, liquid mass	n.a.	89,615		69,991	
12	Total mass, PCB dielectric mass	n.a.	78,950			78,950
13	Total mass	n.a.	877,265			
14	Liquid mass	n.a.	?	n.a.	2,318	n.a.
15	PCB dielectric mass	n.a.	?	n.a.	n.a.	172
Total			?			

At this stage, we will not be concerned with the exact PCB content. While the PCB content was reported in a number of cases, the available data were not sufficient to draw any conclusions, *e.g.* in terms of

[74] Calculated based on Secretariat of the Basel, Rotterdam and Stockholm Conventions, 2014a, 2014b; Secretariat of the Basel, Rotterdam and Stockholm Conventions, 2009, 2010, 2011; GEF, 2014; UN, 2014; UNEP, 2003; UNEP, 2002a, 2002b, 2002c, 2002d, 2002e, 2002f, 2002g, 2002h, 2002i, 2002j, 2002k, 2002l; Basel Convention Regional Centre for French-speaking countries in Africa in Senegal, 2007; Secretariat of the Basel, Rotterdam and Stockholm Conventions, 2014c; Chemical Legislation European Enforcement Network, 2005a, 2005b; CEC, 2006; UNEP Chemicals and Waste Branch, 2014

average content. Where accurate information has not been provided, it is assumed to be liquid or equipment is assumed to contain PCB at concentrations greater than 0.005 %.

In order to estimate how much PCB still has to be disposed, the figure of concern for the purpose of this assessment is the total mass. However, in a number of instances, the total mass has not been reported (see the cells shaded in red). It is therefore necessary to provide some estimates. When estimating the total mass for row 5, 6 and 7, it is important to keep in mind that the relevant liquids and equipment vary strongly in terms of mass. It was therefore necessary to have a closer look at the composition of the relevant cells, so as to determine how large the share is for the different categories. The wastes/materials/equipment were reported in a large number of classifications. In order to allow for statistical analysis, they were classified into the following categories (as done for the mass already eliminated): 'Transformers', 'capacitors', 'transformers and capacitors', 'equipment', 'oil', 'drums', 'open applications', 'others' and 'unspecified'. The same concerns noted above with regard to these classifications apply.

In order to obtain a conversion factor for each of these categories, the average ratio between units and mass was calculated taking into consideration all instances where both variables were reported in conjunction. This was done for each of the nine categories (transformers, capacitors etc.) (see Table 7). It should be noted that the average ratios calculated here from the data on the mass to be eliminated differs from those calculated using the data from the mass already eliminated.

Table 7: Conversion factors to convert units to total mass (note: all values rounded)[75]

Type	Units (#)	Total mass (t)	Ratio
Transformers	33,158	87,129	2.628
Capacitors	139,746	7,061	0.051
Transformers and capacitors	430,674	119,140	0.277
Equipment	27,191	39,018	1.435
Oil	17	36	2.143
Drums	141	59	0.418
Open applications	-	-	n.a.
Others	244	303	1.244
Unspecified	3,668	16,101	4.390

As can be seen, a very high ratio applies for the category 'unspecified'. Regarding the other categories, in line with what was expected, the ratio was highest for transformers. In contrast with the ratio calculated for the mass eliminated to date, this ratio can be considered realistic in the light of expert judgement[76]. In line with expectations given their typical size, the ratio to convert units of capacitors into mass was among the lowest.

This conversion factor was then multiplied with the number of units reported for each of the categories in each of the cases where the corresponding total mass had not been reported. Subsequently, the thus calculated total mass for each of the categories was summed up in order to get an overall estimate for row 7. As an example, the results for row 7 are shown Table 8.

[75] *Ibid*.

[76] This was also confirmed at the joint 'Expert Meeting on the Effectiveness Evaluation of Implementation of the Stockholm Convention for PCB and Sixth Meeting of the Advisory of the PCB Elimination Network (PEN)', held on 14-16 December, 2015, in Brno, Czech Republic. The meeting report will soon be made available.

Table 8: Composition of instances where only the units are available (note: all values rounded)[77]

Composition of row 7			
Type	**Units**	**Conversion factor**	**Total mass**
Transformers	1,713,793.000	2.628	4,503,329
Capacitors	1,176,812	0.051	59,461
Transformers and capacitors	27,014	0.277	7,473
Equipment	4,871,856	1.435	6,990,886
Oil	60,523	2.143	129,697
Drums	-	0.418	-
Open applications	-	n.a.	n.a.
Others	520,090	1.244	646,849
Unspecified	1,372	4.390	6,023
Total	8,371,460		**12,343,719**

The same approach was taken to calculate the results for the other cases where only one variable was available, namely row 14 (only liquid mass available) and row 15 (only the PCB dielectric mass available). The results are shown in Table 9 and Table 10.

Table 9: Composition of instances where only the liquid mass is available (note: all values rounded)[78]

Composition of row 14			
Type	**Liquid mass**	**Conversion factor**	**Total mass**
Transformers	30	3.659	110
Capacitors	-	7.813	-
Transformers and capacitors	-	n.a.	n.a.
Equipment	2,201	2.702	5,947
Oil	87	1.247	108
Drums	-	1.704	-
Open applications	-	n.a.	n.a.
Others	-	1	-
Unspecified	-	3.217	-
Total	2,318		6,165

[77] *Ibid.*
[78] *Ibid.*

Table 10: Composition of instances where only the PCB dielectric mass is available (note: all values rounded)[79]

Composition of row 15			
Type	**PCB dielectric mass**	**Conversion factor**	**Total mass**
Transformers	0	4.005	-
Capacitors	27	3.746	102
Transformers and capacitors	-	11.956	-
Equipment	-	3.769	-
Oil	45	1.002	45
Drums	-	n.a.	n.a.
Open applications	100	1	100
Others	-	3.711	-
Unspecified	-	3.677	-
Total	172	n.a.	247

For rows 5 and 6, more than one variable was reported. For row 5, data are available on the number of units and liquid mass; for row 6, data are available on the number of units and the PCB dielectric mass. Accordingly, the two sets of conversion factors (i.e. those to convert units to total mass as well as those to convert liquid mass to total mass for row 5; those to convert units to total mass as well as those to convert PCB dielectric mass for row 6) were used to estimate a range of possible values for row 4 (i.e. the cases where the number of units and the mass of oil were reported but not the total mass). Consequently, two estimates can be made for both rows. Then, the mid-range was taken in both cases for the purpose of providing a single estimate of the total mass eliminated to date. The fact that the ranges are much smaller than when calculating the mass already eliminated suggests a higher degree of certainty.

The overall results are shown in Table 11.

[79] *Ibid.*

Table 11: Total mass of liquids and equipment containing or contaminated with PCB (note: all values rounded)[80]

Row	Units	Total mass (t)	Solid mass (t)	Liquid mass (t)	PCB oil mass (t)
1	335,774	168,402	122,385	44,897	
2	279,730	91,476	69,534		22,511
3	21	29	29		
4	19,314	8,941			
5	81,389	Between 31,842 and 34,301 or 33,071		8,281	
6	602,430	Between 160,085 and 357,081 or 258,583			41,918
7	8,371,460	12,343,719			
8	n.a.	65,171	17,948	15,042	
9	n.a.	318	187		131
10	n.a.	12,537	12,537		
11	n.a.	89,615		69,991	
12	n.a.	78,950			78,950
13	n.a.	877,265			
14	n.a.	6,165		2,318	
15	n.a.	247			172
Total		Between 13,937,221 and 14,131,759 or **14,034,490**			

Thus, if all sources of information listed above are taken into consideration, the total mass of PCB liquids and equipment that still needs to be eliminated is estimated at *ca.* 14 million tonnes. Adding the data available for the non-parties raises the amount to ca. 16.7 million tonnes.

This estimate is at best indicative, given the many limitations discussed above. A number of reasons suggest that the estimate of *ca.* 14 million tonnes may in fact be an underestimation. As noted previously, most inventories are preliminary in nature. They typically do not cover open applications and instead focus on a few 'main' categories (typically transformers), only some regions, and only certain sectors (typically the electricity sector). Where countries reported all equipment that could potentially contain PCB, rather than only the share that is suspected to contain PCB, the data were not included. Moreover, it can be assumed that many PCB holders, especially in developing countries, do not report accurately in order to avoid management costs. Also taking into account the potential for dilution and cross-contamination, the estimate may thus be too low.

Meanwhile, some figures may be too high, since in some cases large amounts of equipment that are 'PCB-assumed' were reported and included in the analysis, although its share with a PCB content above 0.005 % may be relatively small. Most notably, it is highly probable that significant amounts included in this estimate have in fact already been disposed. Even where these are covered in the gathered data on the amounts already eliminated, it was rarely possible to determine in how far these were actually the same ones reported elsewhere as existing stockpiles. A substantial share of inventories relied on the use of preliminary screening tools, lacking subsequent chromatographic verification. Field experience suggests

[80] *Ibid.*

that where verification was done, the amounts of PCB waste containing/contaminated with PCB were significantly lower.

Compared to earlier estimates, the 14 million tonnes may be considered a realistic estimate. Prior to the fourth meeting of the COP to the Stockholm Convention, the Secretariat reviewed the data contained in the first NIPs (submitted until December 2008) and came to the conclusion that almost 6.5 million tonnes of PCB contaminated oil together with almost 0.5 million tonnes of contaminated equipment were reported by the Parties. Since inventories are now more comprehensive and because additional sources have been used in this estimate to close some of the gaps, it is not surprising to see that the amount is higher than previously estimated, even though considerable amounts have been eliminated in the meantime. However, another analysis by the Secretariat had indicated that less than 3 million tonnes remain to be eliminated.

A closer look at the data reported by Parties reveals that most of the amounts have been reported by Japan. Removing Japan from the data set decreases the total mass still to be eliminated to ca. 2.5 million tonnes. While it is reasonable to assume that the region with the highest installed electricity capacity[81] also has the largest amount of PCB still to be eliminated, the figure seems disproportionally high. As previously noted, Japan provided a very comprehensive and detailed inventory. For categories such as transformers, capacitors and lighting ballasts, Japan reported inventories that are extremely high compared to other countries[82]. As indicated, a substantial amount reported by Japan is labelled as having concentrations below 0.5 %. A significant share of this may in fact have concentrations below the 0.005 % threshold, as the legal threshold in Japan is lower than that provided in the Stockholm Convention. Data taking the 0.005 % as threshold is not available. However, Japan also reported large amounts above 0.5 %, unlike many other countries with similar industrial structures. Therefore, the high figures reported by Japan should be seen as an indication that most, if not all other countries reported quantities that are unrealistically low, meaning that the total mass still to be eliminated is probably much larger than the estimated 14 million tonnes.

Breaking the total mass to be eliminated down by categories, equipment accounts by far for the largest share, namely more than half, followed by the transformers, at about one third. The overall distribution is shown in Figure 10. It should be noted that this distribution reflects a reporting bias. Most countries do not report on closed and semi-closed applications other than transformers and capacitors. Moreover, the large amounts of open applications still to be eliminated were identified and reported in very few instances. Open applications have almost exclusively been reported by a few countries belonging to the WEOG. In Switzerland for example, according to a national survey conducted in 1999-2002, it has been estimated that about 50 t-150 t of PCB were present at that time in joint sealants of existing buildings erected between 1955 and 1975[83]. Taking into account potential diffusion and cross-contamination from open applications, the amount of liquids and equipment to be eliminated would assumedly be much larger.

[81] US Energy Information Administration, 2015

[82] In its third national report, Japan reported among others ca. 90 thousand tonnes of PCB-contaminated oil, almost six million units of lighting ballasts, ca. 1.7 million pole-mounted transformers, and ca. 1.7 million low-voltage capacitors. (Ministry of Foreign Affairs of Japan, 2014). Upon request, the Focal Point for the National Report specified that as of 2014, Japan has the following inventory above concentrations of 0.5 %: 6,325 transformers, 129,758 capacitors, 4,734,559 lighting ballasts; below 0.5 %: 30,290 high voltage transformers, 46,698 low voltage transformers, 981,597 low voltage capacitors, 1,428,486 pole mounted transformers, among others.

[83] Federal Office for the Environment of Switzerland, 2014

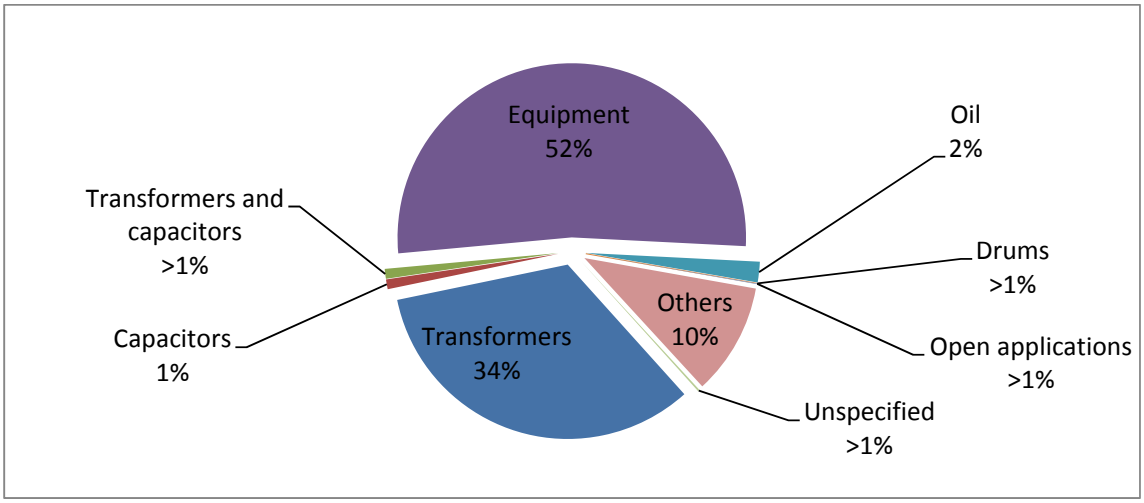

Figure 10: Share of total mass to be eliminated by category[84]

3.3.2. Regional Distribution

Figure 11 shows the share of the total mass of 14 million tonnes in need of elimination by region. It should again be noted that this figure and the corresponding estimates are based on the data that has been reported, meaning that this may not be an accurate representation of the situation.

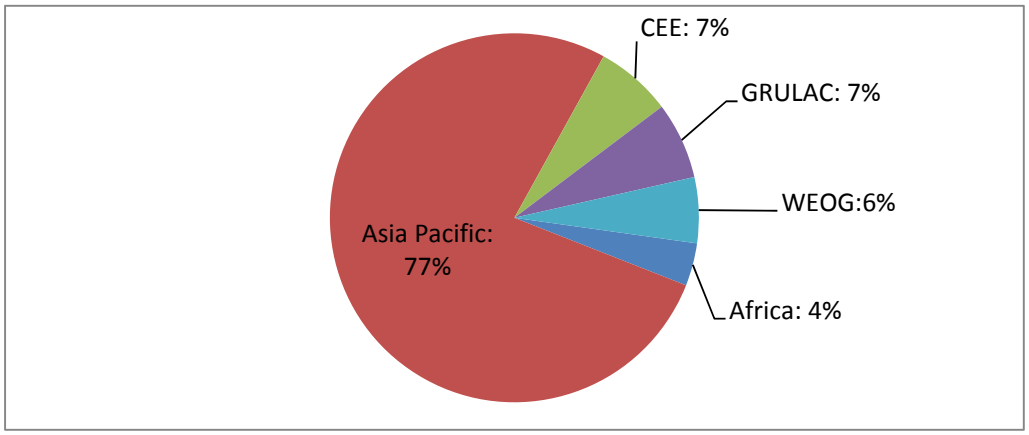

Figure 11: Share of the total mass still in need of elimination by region[85]

The relatively small amount reported for the WEOG (taking into account past and present electrical capacity) may be considered accurate, given that most countries report that they practically eliminated all liquids and equipment containing PCB. In fact, a number of countries from the WEOG report that virtually all equipment with a PCB content greater than 0.005 % have been removed from use and eliminated. Open applications are the notable exception, but have rarely been reported. As regards Africa and GRULAC, historical uses are relatively low. Meanwhile, it is evident that the estimates for the African Region and – to a lesser extent – GRULAC are far below the amounts that are in fact still in need of elimination. Inventories are particularly wanting for the African Region. Moreover, as noted previously, a number of countries from these regions have not reported any data.

[84] *Ibid.*

[85] Calculated based on Secretariat of the Basel, Rotterdam and Stockholm Conventions, 2014a, 2014b; Secretariat of the Basel, Rotterdam and Stockholm Conventions, 2009, 2010, 2011; GEF, 2014; UN, 2014; UNEP, 2003; UNEP, 2002a, 2002b, 2002c, 2002d, 2002e, 2002f, 2002g, 2002h, 2002i, 2002j, 2002k, 2002l; Basel Convention Regional Centre for French-speaking countries in Africa in Senegal, 2007; Secretariat of the Basel, Rotterdam and Stockholm Conventions, 2014c; Chemical Legislation European Enforcement Network, 2005a, 2005b; CEC, 2006; UNEP Chemicals and Waste Branch, 2014

About 77 % of the total mass of liquids and equipment containing or contaminated with PCB still in need of elimination has been reported by the Asia-Pacific Region. Ca. 7 % of the total mass to be eliminated was reported by the GRULAC Region and CEE, followed by the WEOG (ca. 6 %), and Africa (ca. 4 %). Removing Japan from the data set would yield a much more balanced picture, as shown in Figure 12. Even if Japan is removed from the data set, the Asia-Pacific Region still accounts for the largest share (ca. 34 %).

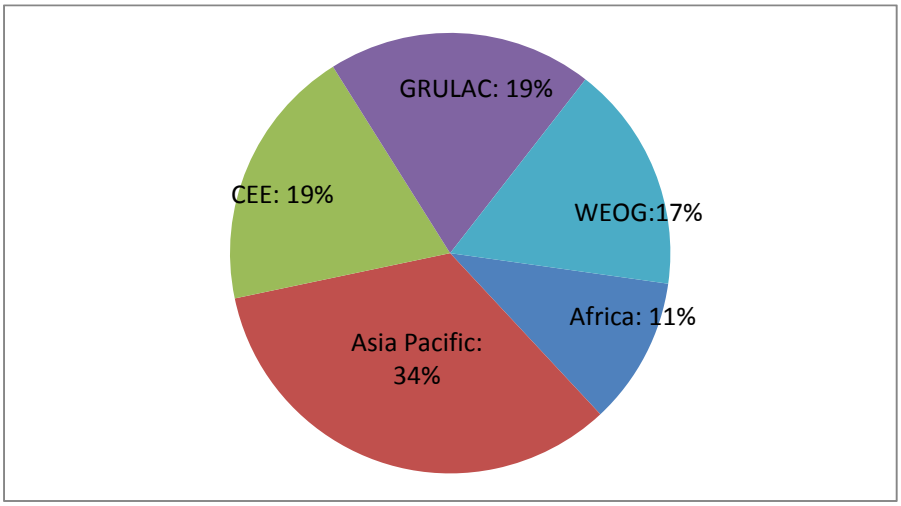

Figure 12: Share of the total mass still in need of elimination by region – without Japan[86]

It is also important to keep in mind that capacities to dispose of the remaining amounts vary considerably. For example, while Japan has reported large amounts of PCB waste that are still in need of elimination, the country has sufficient elimination capacities and can be considered to be on track towards meeting the goals of the Stockholm Convention. Thus, while the figure may suggest that the Asia-Pacific Region should be prioritized, while GRULAC and the African Region are less of a concern, it can be expected that the situation will look very different in a few years' time, especially if more recent and accurate data become available. Further work also remains for the WEOG, in particular in addressing open applications which have so far largely not been included in inventories.

3.4. Progress toward Eliminating PCB

Adding the ca. 14 million tonnes in need of elimination to the ca. 3 million tonnes estimated to have been eliminated gives a total of *ca.* 17 million tonnes. Thus, *ca.* 17 % of the total mass of liquids and equipment containing or contaminated with PCB has already been eliminated, according to the data available. *Ca.* 83 % of the total thus remain to be eliminated.

Comparing the total figure of ca. 17 million tonnes with the ca. 1.3 million tonnes of PCB that were approximately produced and assuming that ca. one-third of the PCB was released to the environment, it follows that each ton of PCB generated created about 20 tonnes of waste PCB liquids and equipment. However, as highlighted, the estimates for both the mass eliminated and the mass to be eliminated are likely at the low end, meaning that each ton of PCB probably generated much more than 20 tonnes of PCB wastes.

Table 12 provides an overview of the amounts already eliminated, scheduled to be eliminated, still in need of elimination, and the total across regions.

[86] Calculated based on Secretariat of the Basel, Rotterdam and Stockholm Conventions, 2014a, 2014b; Secretariat of the Basel, Rotterdam and Stockholm Conventions, 2009, 2010, 2011; GEF, 2014; UN, 2014; UNEP, 2003; UNEP, 2002a, 2002b, 2002c, 2002d, 2002e, 2002f, 2002g, 2002h, 2002i, 2002j, 2002k, 2002l; Basel Convention Regional Centre for French-speaking countries in Africa in Senegal, 2007; Secretariat of the Basel, Rotterdam and Stockholm Conventions, 2014c; Chemical Legislation European Enforcement Network, 2005a, 2005b; CEC, 2006; UNEP Chemicals and Waste Branch, 2014

Again, region differences are very pronounced. Table 12 provides an overview of the progress of each region towards elimination of PCB, *i.e.* the share of each region's total that it has already disposed of. Available data suggest that the African Region has the longest way ahead towards achieving the goal of eliminating PCB: *Ca*. 98 % still need to be eliminated. The approximate shares lie at 86 % for the Asia Pacific Region and GRULAC, 81 % for CEE and 36 % for WEOG.

Table 12: Overview of progress towards eliminating PCB

Region	Eliminated		To be eliminated		Total
	Tonnes	Share (%)	Tonnes	Share (%)	
Africa	6,056	2	269,736	98	275,792
Asia-Pacific	2,017,916	14	12,374,821	86	14,392,736
CEE	111,009	19	482,076	81	593,085
GRULAC	76,772	14	484,768	86	561,540
WEOG	744,267	64	415,464	36	1,159,731
All	**2,956,019**	**17**	**14,026,865**	**83**	**16,982,885**

As previously noted, an explanation for the surprisingly small total for the WEOG is that very large amounts have already been eliminated prior to the periods covered by most of the available sources of information. Thus, many of the countries of the WEOG simply reported that liquids and equipment containing PCB have virtually been disposed, not offering any quantitative data.

Additional gaps in this analysis include the large amounts of PCB that have been landfilled or released to the environment. In the EU alone, more than 200,000 tonnes are landfilled[87]. In the US, more than 20 % of the 700 thousand tonnes of pure PCB produced were landfilled by the time production was terminated[88]. It has been estimated that approximately one-third of the PCB that has been produced globally was released to the environment[89]. In the US, by 1976, ca. 10 % of the total production of PCB was released to air, water and soil[90]. It has also been estimated that 26 million cubic meters of soils are contaminated with PCB in the US alone[91].

[87] BIPRO, 2005, p. 56
[88] As of 1976, 150,000 of the 700,00 tonnes of pure PCB produced had been landfilled (US EPA, 1997).
[89] Hansen, 1987
[90] US EPA, 1997
[91] CEC, 1998

4. Discussion, Conclusions and Recommendations

Limited data

Existing data are severely limited and many challenges have been encountered in gathering and evaluating information. It should hence be noted that the numbers presented in this report represent rough estimates, suitable only for identifying larger trends. Further work will be necessary in order to refine the present assessment as well as to incorporate additional information as it becomes available. Such further work would include, among others, a more qualitative reading of the available data and efforts to fill the remaining gaps in cases where inventories are incomplete or non-existent.

The 2028 Deadline

It is beyond doubt and confirmed by this assessment that the Stockholm Convention, including development of the National Implementation Plans, as well as the many GEF-funded projects had an important beneficial impact in drawing attention to the PCB issue, in raising awareness, in building capacity and in eliminating liquids and equipment. Nonetheless, the limited information available is sufficient to highlight the need to expedite and intensify efforts to eliminate PCB to meet the 2028 goals of the Stockholm Convention. While some progress – although difficult to quantify – has been made toward the elimination of PCB, the majority of countries (with some notable exceptions) are currently not on track to achieve the environmentally sound management of PCB by 2028. According to this assessment, ca. 83 % of the total mass of PCB liquids and equipment remain to be eliminated. A strong argument can be made that the scope of the challenge of ensuring the environmentally sound management of PCB by 2028 has been severely underestimated. A number of urgent steps have to be taken by the Parties.

Legislation and national action plans

The basis of any effective action to be is the existence of appropriate regulatory frameworks and national action plans. Countries should be encouraged to define progressive plans for the environmentally sound management of PCB, including its elimination, with strict timelines as part of national hazardous waste management plans and to ensure continuous monitoring of progress toward the Stockholm Convention targets. These plans need to address the entire life cycle of PCB, including prevention and safety considerations. They should be developed in close cooperation with holders of PCB as well as other concerned actors. It is necessary to expand participation beyond the traditional electricity sector and include sectors such as the military. In order to ensure effective implementation, national action plans should be approved through a dedicated legislative act and enforced by the relevant authorities, including through fines, where appropriate. Both positive and negative incentives are necessary to advance the phasing out and environmentally sound management of PCB liquids and equipment. Each country should explore the optimal and most cost-effective solution given its specific domestic background and circumstances.

Inventories

Most national inventories, forming the basis of any action to be taken, are yet preliminary in scope. Even for closed applications, comprehensive data are still lacking. Therefore, PCB inventories need to be harmonized and completed as a basis for reporting accurately and drafting revised national action plans. Inventories need to be undertaken in a systematic manner, avoid estimates wherever possible and cover all types of equipment, sectors and geographical areas. For this purpose, countries may need to consider the establishment and periodic updating of a national database. In many cases, projects are based on wrong baselines, with the consequence that financial resources are insufficient and targets cannot be achieved. Appropriate regulatory and legislative frameworks will be necessary to ensure that holders of PCB provide the requested information necessary for inventory development/update. Comprehensive inventories should be developed during the updating/implementing of the NIPs.

Reporting

It is strongly recommended that steps are taken to ensure that comprehensive, clear, reliable and well-structured data on the amounts of PCB already eliminated and – most importantly – the amounts still to be eliminated are reported. In order to allow for comparability of the data, it is recommended to adjust the reporting format based on the experience from the first three reporting cycles. It needs to be ensured that a unitary reporting format is followed, which should be aligned with the national reporting under the Stockholm Convention. Accordingly, methodologies for inventories should be streamlined. These need to be closely linked with the process to update the NIPs.

Financial resources and cost-benefit ratio

Given the large amounts that still need to be eliminated, it may also be necessary to increase the cost-effectiveness of interventions. Projects can be designed in a way as to strengthen human and infrastructure capacities in the long term, beyond the duration of the project. If appropriately designed, initiatives to manage PCB in an environmentally sound manner will have a positive spill over effect, for example by establishing infrastructure that can be used for the transport of other hazardous wastes. Notwithstanding, large additional funds will be necessary to meet the objective of the Convention. Linking the sound management of PCB with the SDGs and integrating it in new national development plans may prove a successful strategy to place the issue on the agenda and attract funding. Innovative approaches need to be followed and partnerships established. A critical step is to secure participation and contributions from the private sector.

The amounts already disposed and scheduled for disposal under GEF projects is very small compared to the estimated total amount still to be eliminated and can thus merely be a starting point. In order to allow for informed decision-making, it may prove useful to compile information on the costs of elimination (including from completed and ongoing GEF projects) and the cost-effectiveness of available technologies as well as to identify steps that can be taken to reduce such costs or increase financial leverage. Many developing countries may first have to focus on the 'low-hanging fruits', namely to eliminate the main source of PCB, that is large transformers containing high concentrations of PCB.

Capacity-building and technology transfer

While technologies and capacities for the elimination or irreversible transformation of PCB are available, with many countries already having eliminated substantial amounts of PCB either domestically or via export, additional financial resources are needed, in particular for developing countries and countries in transition. Meanwhile, in many cases, the technology is available, but the staff is not properly trained in its use. Human capacity and expertise created during the inventory preparation, NIP updating process or GEF-funded projects needs to be maintained at the national level. Relevant activities and projects need to ensure that the correct target groups are identified and trained. This also includes awareness-raising activities, in particular among PCB holders. Technology transfer will also be needed to phase out the remaining production of PCB. In addition, it is important for many countries to strengthen their capacity for monitoring of PCB in the environment as well as the identification of PCB, including laboratory analysing for PCB content. Exchange of information, experience and lessons learned may be a valuable and cost-effective tool to support countries in need of assistance. Furthermore, active involvement of the private sector and the establishment of joint ventures is a critical step.

Open applications and contaminated sites

Databases should also cover open applications which have so far rarely been given attention despite the provision in Annex A, Part II, para (f) and them being among the main sources of PCB releases to the environment and thus a major threat to human health. Most of the countries that have submitted their updated NIPs envisage addressing open applications; however not as a priority. The development of a standardized methodology for the undertaking of inventories for open applications is strongly

recommended. Trainings will also need to be delivered. Sites contaminated with PCB have also not yet received the attention that would be warranted given the large potential for releases to soil and water.

These efforts are all the more urgent, since a large share of the PCB that was produced has already been released to the environment. Handling and storage practices that are not sufficiently sound and not in line with the Basel technical guidelines may trigger further accidents and releases, with severe consequences on human health and the environment. In light of its toxicity and the large quantities of PCB still in use or in stockpiles for disposal, the environmentally sound management and elimination of PCB should be made a priority.

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Annex A: Reporting template

UNEP Chemicals Branch (2014) | Collection of information | PCB use, storage, trade and destruction

To the extent possible, please fill out where relevant or appplicable; expand cells or rows where necessary. Thank you

Name of party/organisation/institution:
Contact person:
Email:
Telephone:
Date of information (dd/mm/yyyy): 10/13/2014

Amount of PCB destroyed within national boundaries

Country	Site of destruction	Year	Mass (ton)			Number of pieces of equipment	Type of equipment** *	Type of PCB*1	PCB content						Technology	Overall costs (USD) ****	Financial assistance?		Project			Contacts		Source of information	Comments
			Equipment	Oil/liquid	Total				>10 % or 100 g/kg	> 0.05 % or 500 mg/kg	> 0.005 % or 50 mg/kg	< 0.005 % or 50 mg/kg	PCB content not known				GEF IA	Other	Identification	Key steps	Major outputs	National	IA		
					0																				
					0																				
					0																				

Amount of PCB exported to foreign country for destruction

Country	Country of export /full country name)	Year	Mass (ton)			Number of pieces of equipment	Type of equipment** *	Type of PCB*1	PCB content					Y or A code (Basel Convention)	Technology	Overall costs (USD) ****	Financial assistance?		Project			Contacts		Source of information	Comments
			Equipment	Oil/liquid	Total				>10 % or 100 g/kg	> 0.05 % or 500 mg/kg	> 0.005 % or 50 mg/kg	< 0.005 % or 50 mg/kg	PCB content not known				GEF IA	Other	Identification	Key steps	Major outputs	National	IA		
					0																				
					0																				
					0																				
					0																				

Amount of PCB imported from foreign country for destruction

Country	Country of import /full country name)	Year	Mass (ton)			Number of pieces of equipment	Type of equipment** *	Type of PCB*1	PCB content					Y or A code (Basel Convention)	Technology	Overall costs (USD) ****	Financial assistance?		Project			Contacts		Source of information	Comments
			Equipment	Oil/liquid	Total				>10 % or 100 g/kg	> 0.05 % or 500 mg/kg	> 0.005 % or 50 mg/kg	< 0.005 % or 50 mg/kg	PCB content not known				GEF IA	Other	Identification	Key steps	Major outputs	National	IA		
					0																				
					0																				
					0																				
					0																				

Amount of PCB stored safely awaiting destruction (domestic or export)

Country	Site of storage	Year	Mass (ton)			Number of pieces of equipment	Type of equipment** *	Type of PCB*1	PCB content						Storage arrangement	Overall costs (USD) ****	Financial assistance?		Project			Contacts		Source of information	Comments
			Equipment	Oil/liquid	Total				>10 % or 100 g/kg	> 0.05 % or 500 mg/kg	> 0.005 % or 50 mg/kg	< 0.005 % or 50 mg/kg	PCB content not known				GEF IA	Other	Identification	Key steps	Major outputs	National	IA		
					0																				
					0																				
					0																				
					0																				

Amount of PCB still available/in use or in need of safe storage/destruction

Country	Owner/holder of PCB	Year	Mass (ton)			Number of pieces of equipment	Type of equipment** *	Type of PCB*1	PCB content						Safeguarding measures		Financial assistance?		Project			Contacts		Source of information	Comments
			Equipment	Oil/liquid	Total				>10 % or 100 g/kg	> 0.05 % or 500 mg/kg	> 0.005 % or 50 mg/kg	< 0.005 % or 50 mg/kg	PCB content not known				GEF IA	Other	Identification	Key steps	Major outputs	National	IA		
					0																				
					0																				
					0																				
					0																				

* 50 mg/kg is equivalent to 0.005% or 50 ppm
** E.g. transformer oil
*** E.g. capacitor
**** Please indicate if transport is included