# PCB INVENTORY AND MANAGEMENT CHALLENGE & PROGRESS IN SRI LANKA

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## Introduction

The Stockholm Convention on Persistent Organic Pollutants (POPs)[1] was adopted in 2001 and entered into force in 2004[1]. It is a global environmental treaty that aims to protect human health and the environment from POPs[1]. Exposure to POPs can lead to serious health effects including certain cancers, birth defects, dysfunctional immune and reproductive systems together with greater susceptibility to disease. Countries are developing National Implementation Plans (NIPs) for controlling, managing and reducing POPs release and stockpiles in the respective countries. These NIPs should be updated as appropriate in particular when new POPs are listed.
Sri Lanka has ratified the Stockholm Convention in 22nd December 2005 and has developed the first NIP in June 2006[2]. Within the first NIP of Sri Lanka, POPs pesticides, polychlorinated biphenyls (PCBs) and unintentional POPs (with focus on PCDD/PCDF) have been considered.
In particular the inventory and management of PCBs have been found highly demanding in respect to time and resources. A recent survey of global PCB inventory and management by UNEP revealed that the stockpiles of PCB contaminated oil and equipment are estimated to be eliminated are c. 9.3 million tonnes[3] and therefore even larger than reported in the first global survey in 2008 where estimates were between 3 and 6 million tonnes[4].
Also for Sri Lanka over the last 10 years not much progress has been made in respect to PCB management.
Sri Lanka started the update process of the NIP with the support of UNIDO as implementing agency. Within this process also the situation of the PCB stockpile in Sri Lanka has been further assessed and was updated.

In this study the situation on PCB inventory and the challenges with PCB management and control in Sri Lanka is described. Also possible further activities to overcome the challenges are shortly described.

## Materials and methods

The contamination of PCB in transformer oil has been assessed by using the Dexil Clor-N-oil 50 PCB screening test kit. The test kit was developed based on the U.S. EPA Method 9079. Chlorines are removed from the PCB molecule using an organo-sodium reagent. The resulting chloride ions are measured using a colorimetric indication that the concentration of PCBs is above or below 50 ppm.
Confirmation analysis for PCB content in transformer oils were carried out by GC/MS and GC/ECD analysis.
For GC analysis 0.1 g of transformer oil was measured into a 10 ml vial and 5 ml isooctane was added. The content was shaken for 1 minutes. 0.1 g florisil was added and Vortexes for 3 minutes. The supernatant was transferred into a GC vial. GC-ECD analysis was performed with injection volume of 1 µl (inlet 275 $^0$C / splitless, oven 100 $^0$C 0.8 min, 15 $^0$C per min to 300 $^0$C 2 min, column flow 2 mL/min, ECD detector 308 $^0$C). Arochlor 1242, Arochlor 1254, and Arochlor 1260 were used as PCB standards to quantify PCB content in transformer oils measured.
The total amount of PCB was calculated by extrapolating the positive tested PCB fraction of tested transformers to the total amount of transformers present in Sri Lanka.
Destruction tests of PCB have been performed in a cement kiln in Sri Lanka. Details on this test trail can be found elsewhere[5].

## Results and discussion

***PCB inventory development***

The primarily PCB inventory in the first NIP focused on the transformers which exists within the power sector. This was considered by far the largest volume of PCB in Sri Lanka and therefore had the highest priority.
In today's context and as at 2005 the Ceylon Electricity Board (CEB) covers almost the entire electricity generation, transmission and distribution of electricity throughout the country. Lanka Electricity Company Ltd (LECO) covers fraction of the distribution system of the power sector. Lanka Transformer Limited (LTL) is the sole manufacture of transformers in Sri Lanka. Therefore these three agencies are considered as the main entities

that deal directly with transformers and capacitors. It was estimated by the preliminary inventory that approximately 2210 transformers manufactured before 1986 are potentially contaminated with PCBs.

Approximately 1% of total transformers belonging to CEB (16185) were tested (177) in the preliminary PCB inventory with approximately 60% of tested transformers contained PCBs. Table 1 summarizes the distribution of PCB in positive tested transformers (>50 ppm) according to the data developed for the first preliminary inventory in 2006. A minor share of the transformers contained pure PCBs (less than 3% of the tested transformers). The largest share of positive tested transformers contained PCBs contaminated oil (mainly 50 ppm to 2000 ppm). In some provinces 100% of tested transformers had PCB levels above 50 ppm (table 1) while in other provinces the levels in tested transformers where 13% (table 1). The reason has not been revealed but might stem from maintenance practices.

In the first screening it was also revealed that transformers produced after 1986 were contaminated with PCBs (up to 2000 ppm) by cross contamination from maintenance. Therefore also these newer transformers need to be considered to some extent in the inventory development and further management.

**Table 1:** Preliminary inventory of PCBs in transformers in the power sector in Sri Lanka

| Geographical zone | Total units | No of sample collected | Total number of sample tested from total collected | PCB positive (>50ppm) | % sampled size from total unit | %Tested from sampled size | %Tested from total units | % Positive (>50ppm) from sampled size | % Positive (>50ppm) from total units |
|---|---|---|---|---|---|---|---|---|---|
| Central Province | 1451 | 62 | 35 | 20 | 4 | 56 | 2 | 57 | 1 |
| Eastern Province | 1122 | 18 | 0 | 0 | 2 | 0 | 0 | 0 | 0 |
| North Central Province | 958 | 16 | 9 | 3 | 2 | 56 | 1 | 33 | 0 |
| North Province | 303 | 2 | 2 | 2 | 1 | 100 | 1 | 100 | 1 |
| North Western Province | 1739 | 30 | 8 | 1 | 2 | 27 | 0 | 13 | 0 |
| Sabaragamuwa Province | 1281 | 37 | 7 | 4 | 3 | 19 | 1 | 57 | 0 |
| Southern Province | 1818 | 44 | 14 | 14 | 2 | 32 | 1 | 100 | 1 |
| Uva Province | 1070 | 30 | 7 | 7 | 3 | 23 | 1 | 100 | 1 |
| Western Province | 6443 | 442 | 95 | 56 | 7 | 21 | 1 | 59 | 1 |
| | 16185 | 681 | 177 | 107 | 4 | 26 | 1 | 60 | 1 |

The estimated PCB amount is 2,292 tonnes of PCB contaminated transformer oils in the power sector of Sri Lanka based on the analytical data generated in the first NIP and extrapolated for the non tested transformers. The lack of comprehensive testing is a key obstacle for developing countries to develop a comprehensive PCB inventories as a base to meet its obligations within acceptable time duration. The actual value of PCB contaminated transformer oils in Sri Lanka is most probably higher than the predicted volume since e.g. up to now the transformers present in other industries (e.g. cement plants, metal production and plantation) have not been considered in the first inventory and are only addressed now in the current phase of NIP update.

After the development of the first NIP, the last 7 years no specific funding has been given for completing the PCB inventory and for starting with PCB control and management. Also no regulatory frame has been established within the first NIP and follow-up that the owners of the PCB have e.g. to assess their transformers and condensers for the PCB content and to strictly control the waste oils of transformers after their end of life or when changing the oils. Therefore no inventory progress has been made between 2008 and 2014. The waste oils have not been appropriately managed but it has been discovered over the last years that waste oils are reused by different businesses and are distributed in the country (see below).

Within the preparation of the NIP update starting middle of 2014, the PCB inventory has been slightly progressed. It was been recognised that transformers are used not only in the power supply but also in other industries such as metal industries, cement industry and government institutions including e.g. tea states and that they need to be included in the inventory and management within the NIP update. Also that an inventory needs to be developed for condensers for their further environmental sound management.

***Use of PCB by small enterprises and informal sector***
It has been discovered in Sri Lanka that PCB oil from transformers going out of the grid are frequently reused by small companies to fill or refill other transformers. Furthermore the waste oil is used for the production of grease and for corrosion protection of cars[6]. Also waste oils are reused in welding operations with associated human exposure[7]. This demonstrates that transformer oils in Sri Lanka (and most probably in other developing countries) are reused in open applications with associated releases to the environment and human exposure.

***PCB in open applications***
Up to now only PCBs in closed application are elaborated within the Stockholm Convention and related inventories. Therefore PCBs in open application (e.g. former use in sealants, paints, coatings, cutting oils) have not been addressed in the NIP developments in developing countries and are often also not addressed in inventories in industrial countries. However in recent years it has been revealed that the exposure to PCB in open applications has still a high relevance in industrial countries. Also within the PCB Elimination Network (PEN) under UNEP the issue of PCB in open applications have been raised in recent years. While for some industrial countries the use has been documented and for a few countries appropriate management measures have been implemented (e.g. Switzerland[6]), the relevance and the dimension of PCB use in open applications in developing countries has not been clarified. Therefore an assessment of potential use of PCB in open application will be included in the NIP update considering also the above mentioned reuse of transformer oils in open applications.

***Trial test for destruction of PCB in Sri Lanka***
A test burn for the destruction of PCBs in a cement kiln in Sri Lanka has been performed in 2006[5]. For this test, high concentration PCB–oil was transferred in 60 L stainless steel drums. Furthermore PCB contaminated waste from cleaning of the transformers by washing/rinsing with diesel where transferred in 200 L steel drums. The PCB–oil was confirmed to be Pyralene with an average concentration of 59% of PCB, 36% trichlorobenzene and 5% tetrachlorobenzene. The test was conducted in a state of the art pre-calciner kiln with appropriate monitoring scheme. The test were organized in a three day test burn. The monitoring results demonstrated that the selected cement kiln was able to destroy PCB in an environmental sound manner with a destruction and removal efficiency (DRE) better than 99.9999% at the highest PCB feeding rate[5]. Also unintentionally formed POPs (PCDD/PCDF and HCB) were monitored in the test burn and no additional formation of unintentional POPs were discovered in the test burn.[5]

***Cost for monitoring, management and destruction***
The costs for managing the PCB present in Sri Lanka will be high. Expenses are needed e.g. for:
- Monitoring of PCB in transformers
- Monitoring of PCB condensers
- De-caning and developing a storage of PCB containing oils and equipment
- The management of these equipments and transport
- The cost for the destruction or recycling of PCB contaminated oils
- External cost of health of impacted population and environment. The health cost of PCB contamination in Sri Lanka has not been assessed. These costs might be high considering the distribution of PCB in the informal sector for welding, the recycling into grease and the use for corrosion protection of vehicles with the related exposure to workers, consumers and the environment
- The cost for the assessment, securing and possible remediation of PCB contaminated sites.

The individual cost for these tasks can currently only roughly be estimated since e.g. the technology for destruction has not been chosen. It has been estimated that the cost of exporting PCB for destruction to industrial countries are US$ 2000 to 5000/tonne.[4,9] There is a need of reducing the cost of PCB treatment/tonne since the estimated cost for the global PCB stockpile already for the former assumed 3 million tonnes[4] were US$ 6 to 15 billion[9] and would increase for the updated global inventory (approx. 9.3 million tonnes[4]) by three times. This would be 50 to 125 times the total Global Environment Facility (GEF)-6 budget for all POPs for 2014 to 218 (375 million). Currently the cost for PCB management are carried by international projects from GEF and co-financing by national funds and from owners of the PCB. However the (former) PCB producers and producers of PCB containing transformers and condensers are currently not involved in co-financing. Considering that there is a large gap in financing the global management of PCB in developing countries and considering that the profit for PCBs were made by these companies a fair contribution of these firms to the global management of PCBs should be considered in the frame of extended producer responsibility (EPR[10]). Several of these companies still exist and have Corporate Social Responsibility (CSR) schemes. Such efforts should include the responsibility for their products they have produced. A dialogue with the responsible companies would be a first step. On the other hand developing country examples for environmentally sound management of PCB at reasonable cost are needed to show a possible way forward. Initial price offer for processing PCB in the Sri Lanka kiln was around US$ 1000/t and therefore considerable lower than the estimated US$ 2000 to 5000/tonne for export. However such projects need a rigorous management and monitoring frame and guidance of an expert considering that POP destruction in a cement kiln recently contaminated a valley in Austria including animals, food and humans [11].

***Upcoming PCB management project and* considerations for a way forward**

The assessment and management of PCB in Sri Lanka showed large challenges in respect to management capacity and needed resources. In particular the use of PCB oils and PCB contaminated oils by the informal sector such as welders or producers of small transformers and the associated likely pollution of sites and humans highlight that the actions towards management of PCB need to be significantly improved and accelerated and the management frame in the countries be strengthened. In particular the regulatory frame and the control need to be strengthened to stop the reuse and recycling of waste oils.

Recently a PCB management project developed with UNIDO has been approved by the GEF. This project aim to establish the frame for PCB management in Sri Lanka and the destruction or the decontamination of PCB contaminated oil and equipment. The project will start in June 2015 with a budget of US $ 4,725,000 grant amount and total budget of US $ 18 million.

For Sri Lanka the upcoming PCB project is considered a key step forward to stop the ongoing PCB distribution and pollution in the country. The total budget of the project based on information during its preparation will likely not be sufficient to manage all PCB containing equipment and waste oils. However if the project can demonstrate that a large amount of the current PCB stock can be managed, a funding for the remaining PCBs should have a high probability to become funded that the deadline set by the convention to phase out all PCB by 2025 and manage all PCB stocks by 2028 might be achieved in Sri Lanka.

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