PCB DISPOSAL – A REVIEW AND OPTIONS FOR SOUTHEAST ASIA

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Introduction

Polychlorinated biphenyls (PCBs) are defined as one of the 12 Persistent Organic Pollutants (POPs) subject to the Stockholm Convention. PCB environmentally sound management and disposal is the common task of its member countries. The Stockholm Convention has been ratified by most South East Asian (SEA) countries, which have similarities regarding PCB features and PCB treatment capacity. Sending PCB wastes abroad for disposal is in consideration of some countries. It is an option, but may not be a sustainable one if looked from regional perspective. This paper will analyze feasibility considerations to address PCB issues and propose PCB disposal processes potentially applied in the South-East Asian region.

Materials and Methods

Technical materials were selected from regional and international sources for review. Interviews with local and international experts and policy makers in the region were also carried out. Collected information was used for feasibility analysis with regional view, including technical, social, economical and environmental perspectives.

Results and discussion:

1. PCBs – the common issue of the South-East Asia

With respect to PCBs, SEA countries have a number of similarities. While they are not PCB producers, South-East Asia imports industrial equipment containing PCBs from developed countries (e.g. electrical transformers and capacitors, heat exchange fluids, paint additives, carbonless copy paper, plastics). In the region, PCBs exist in different matrices (soil, oil, slurries, water, sediment, sludge, electrical equipment, etc.) and are scattered in each country. The region's PCBs quantities are difficult to estimate as almost no comprehensive inventory exists on national level. Since most of SEA countries have adopted the Stockholm Convention, PCB elimination has become a common task of the whole region. However, on technological ground, unlike Western European and North American countries, the region possesses few of PCB treatment technologies such as incineration (in dedicated incinerators and cement kilns) and sodium reduction. On legislative ground, there has not been yet a consistent system of regulations for PCB sound treatment and management, which serves as a reference for selection of technologies appropriate with their respective socio-economic and PCB country-specific situation. Furthermore, due to the differences in legal and social perception on hazardous waste, particularly PCB/POP-containing wastes, treatment of PCB-contaminated wastes has never been looked from regional perspectives.

There are two main possibilities for PCB treatment in the region: (i) exporting PCB to countries owning advanced treatment technologies, and (ii) investing to build PCB centralized treatment facilities in the region. The SEA region does have facilities for PCBs/POPs treatment, e.g. hazardous waste incinerators in Thailand, Malaysia, Singapore [1], cement kiln and Na-tech technology in Vietnam, but still limit in number and need to be further developed. Advanced destruction facilities are mostly located in the US and EU; thus, for safe disposal, countries like the Philippines and Thailand have opted to exporting PCB wastes for disposal overseas where the technologies are available (e.g. The Philippines sent PCB transformers, liquids and contaminated equipment to Belgium and Netherlands [2], Thailand shipped PCBs in transformers to France [3]). When the PCB quantities of a single SEA country are considered small, and a cost-benefit comparison between PCB export and local treatment facility construction is taken into account, the first option may represent a more beneficial practice. Yet, if SEA takes advantage of available technological advances for the appropriate regional treatment facilities, they can create opportunities for all the countries in the region.

Among the world's related technologies, high temperature incineration and chemical dechlorination have multiple advantages and potential for application in SEA. UNEP has also recognized them as proven disposal technologies [4].

2. PCB disposal technologies potentially applied in SEA region

2.1. High temperature incineration

Among incineration processes, the authors recommend two technologies to be applied in the region: (i) high temperature incineration in dedicated hazardous waste incinerators and (ii) co-processing in cement kilns.

a) Hazardous waste incinerators

Process principle: Hazardous waste incinerators uses controlled flame combustion to treat organic contaminants mainly in rotary kilns to cause thermal decomposition of organic contaminants through cracking and oxidation reactions at high temperatures (usually between 850^0- 1550^0C) with a residence time greater than 2 seconds [5].

Limitation of the process: This process needs huge constructional and operational costs. As a traditional treatment technology but incineration does not have a good public perception, for its previous designs were unqualified in terms of safety and environment. However, today's well-equipped and modern incinerators with advanced gas scrubbing and by-products treatment systems are changing public opinion.

Advantages: This is a highly flexible technology, capable of treating wide varieties of all POP waste types (soil, water, sediment, sludge, slurries, oil, equipment) in any concentration with high destruction and removal efficiencies (DREs). DREs of greater than 99.9999% have been reported for treatment of POP waste.

b) Cement kilns

Process principle: The main processes employed in making cement clinker can be classified as either "wet" or "dry" depending on the method used to prepare the kiln feed. In the wet process the feed material is slurries and fed directly into the kiln. In the dry process the kiln exhaust gases are used to dry raw material while it is being milled. The very high temperature of the cement kiln (1450^0C), and with the long residence times (5 - 6 seconds or even longer), destroys most POPs [6].

Potential application: Cement kiln has similar advantages but is not as flexible as hazardous waste incinerators because it cannot accept most electrical equipment. On the contrary, it requires less constructional investment owe to utilization of existing cement plants' kilns. It is also economical when the input of PCB-containing oil can be used as a substitute for fuel in cement kilns. The lack of solid residues after treatment is also a distinct advantage.

2.2. Chemical dechlorination

A variety of chemical dechlorination processes are available today, to name just a few, Alkali metal reduction, Based catalyzed decomposition (BCD), Gas phase chemical reduction, Catalytic hydro-dechlorination. This paper nominates two processes - Alkali metal reduction and BCD.

a) Alkali metal reduction

Process principle: Alkali metal reduction treats wastes with dispersed alkali metal which reacts with chlorine in halogenated waste to produce salt and non-halogenated waste. Typically, the process operates at atmospheric pressure and temperatures between 60˚C and 180˚C. Treatment can take place either in situ (i.e., PCB-contaminated transformers) or ex situ in a reaction vessel [7].

Limitations: It has been noted that PCDDs/PCDFs can be formed from chlorophenols if the temperature in the process is as low as 150^0C. Besides, the process also produces residues or solidified polymer which require to be disposed of in other process. The issues of health and safety should be taken into account due to the risks of fire and explosion caused by this process.

Advantages: The alkali metal reduction process is a relatively simple technology that requires low capital investment. It is flexible owe to (i) its availability in transportable and fixed configurations and (ii) its capability to treat waste in various matrices achieving high DREs (99.9999% for PCBs, aldrin, chlordane). In the region, sodium reduction has been demonstrated with PCB-contaminated oil (up to 10,000 ppm); some vendors have also claimed its capability to treat whole capacitors and transformers. Particularly, this process is economical as it allows the reuse of decontaminated oil and sodium chloride.

b) Based catalyzed decomposition (BCD)

Process principle: The BCD process treats wastes (both solid and liquid) in the presence of a reagent mixture consisting of hydrogen donor oil, alkali metal hydroxide and a proprietary catalyst. When the mixture is heated to above 300°C, the reagent produces highly reactive atomic hydrogen which reacts with organochlorines and other wastes [8]. After the reaction, solid residues are separated from the residual oil by gravity or centrifugation while the oil and catalyst may be recovered for reuse.

Limitations: The BCD process requires high qualified operators, strict safety and inspection procedures and a good maintenance program.

Advantages: This technology is able to treat most POPs in various matrices (solids, liquids) with high DEs (99.9999% for PCBs, DDT, dioxin and furans). Since it can operate either on a continuous basis or by batch, the technology can treat waste in any volume (100kg – tens of tons) provided that higher waste concentrations need longer reaction time. In addition, the health and safety risks associated with this technology operation are generally low. It is also economical when using this process as after treatment the oil can be reused and remaining sludge can be recycled. A BCD plant can be modular, transportable or fixed.

3. Analysis of feasibility considerations

Technical feasibility: The Basel convention recommends that all processes that destroy PCBs, PCTs and PBBs have a 99.9999% DRE and reduce PCB, PBB and PCT levels to below a scientifically-based criterion [9]. Accordingly, the above proposed technologies all meet this recommendation of the Basel convention for transboundary movement for sound disposal of hazardous wastes. Moreover, all the 4 proposed processes of high temperature incineration and chemical dechlorination are proven, commercialized and widely used technologies, particularly capable of treating a wide range of PCB waste matrices. The SEA countries may select among available processes the most appropriate with regional conditions (e.g. PCBs features, infrastructural conditions). For this purpose, regarding infrastructure, SEA may construct a totally new plant or retrofit and upgrade existing facilities, e.g. Bukit Nanas in Malaysia, Holcim in Vietnam and other incinerators in Singapore, Thailand and The Philippines (for incineration) and Na-tech in Vietnam (for sodium reduction), into central facilities to treat PCBs from countries in the region.

Economic-financial feasibility: The Stockholm Convention, on an interim basis, designates the Global Environment Facility (GEF) as the primary, but not exclusive, component of the financial mechanism. Thus, GEF should be considered as an assistance financial source for developing countries in the South-East Asia to fulfill their obligations under the Convention. On-going and follow-up projects for PCBs management which have been granted and pledged by GEF and other donors (e.g. “Vietnam PCB management and disposal demonstration” Project) may create a solid foundation for similar PCB projects on the regional scale. Apart from GEF, the region can mobilize capital from domestic and international sources (EU, GTZ, WB, ADB, SDC, etc.) in an attempt to develop and implement their agenda of PCB environmentally sound management in the region. The payback mechanism for investment taking into account local government budgets, waste generators responsibilities and regional market share is also considerable to increase the economic feasibility of regional option.

Social feasibility: Of the two proposed technologies, high temperature incineration faces more negative public criticism than chemical dechlorination. The public opposition against the construction of a municipal waste incinerator in Broga, Malaysia can make a hard example, which was strong enough to fail a well-planned incineration project. International non-combustion campaign is also another example of social consideration [10]. Hence, a technology’s impacts on safety and health need to be taken into account in the selection process. On the other hand, “not in my backyard” thinking can also be impeditive for the option of building/retrofitting regional PCB treatment facilities in a certain country/territory. To avoid this risk, it is advisable the SEA countries select location for the facilities on a voluntary basis with reasonable compensation and sound management for the risks arisen.

Environmental feasibility: The above-mentioned proposed processes are supposed to be the well-equipped, advanced and modern in their line of technology and have environmentally sound systems for off-gas and by-product treatment, assuring the sound treatment of PCBs and PCB-containing wastes. Furthermore, risk management and safety issues with a full consideration of local conditions should be set as a top priority.

Leadership feasibility: To make possible the option of constructing new facilities or upgrading and utilizing existing ones for PCB treatment of the whole region, there is a need to obtain full support from and consensus among leaders of countries in the region. It is necessary to have a regional forum and a dialog mechanism between governments to collectively deal with issues of POPs and PCBs particularly for the region's sustainable development.

Mutual benefit feasibility: Once the regional PCB treatment facilities option is done, it will benefits participatory countries in terms of PCB management and disposal capacity building, reduction of transport costs for countries without treatment facilities, and assurance of a sufficient input for the regional facilities with waste supply from most countries in the region. However, clear benefits and responsibilities of each participatory party, of both the host and the customer countries, can only be realised with close consultation, cooperation among countries in the region coupled with a deep cost-benefit analysis and social impact assessment for the options, and supports from international communities.

4. Conclusions

With the close cooperation and current trend of integration in South-East Asia, there is an opportunity to develop regional PCB treatment facilities which certainly benefit all countries involved.

High temperature incineration is one option taking the advantages of existing facilities in the region. Chemical dechlorination should be another potential solution owe to its flexible and mobile nature, public support, suitable for scattered, small volume and low-level PCB-contaminated wastes and equipment in the region.

Regional view, social-economic consideration and combined market share are the keys to realise the opportunity.

Acknowledgements

The authors gratefully acknowledge the support of the "Vietnam PCB management and disposal project" (WB/GEF-PCB) and "Environmentally sound Management and disposal of PCB in electrical systems – a pilot project for PCB-elimination in Vietnam" (SDC-PCB).

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