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SOUND MAMAGEMENT OF HBCD IN INSULATION PRODUCTS AND WASTES FROM CONSTRUCTION AND DEMOLITION IN TYPICAL ASIA-PACIFIC COUNTRIES

Basel Convention Regional Center for Asia and the Pacific/ Stockholm Convention Regional Centre for Capacity-building and the Transfer of Technology in Asia and the Pacific

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PART I：

HBCD in insulation products and wastes from construction and demolition in China

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1. Background

Hexabromocyclododecane (HBCD) is a widely used brominated flame retardant, mainly as an additive in following four product types: expanded polystyrene (EPS), extruded polystyrene (XPS), high impact polystyrene (HIPS) and textile coatings. The most significant use of EPS and XPS is in the building and construction sector which accounts for approximately 90% of the total HBCD consumption (Climate and pollution Agency, 2010). In textiles, HBCD is used in back-coatings for upholstery and other interior textiles (POPRC, 2011).

The technical HBCD product mainly consists of three diastereoisomers:a-, b-, and c-HBCD with proportions of 10–13%, 1–12%, and 75–89%, respectively (Covaci et al., 2006).Identified with POPs characteristics, the technical HBCD was listed in Annex A to the Stockholm Convention in May 2013. Due to its widespread use and physical/ chemical properties, HBCDs has become a ubiquitous contaminants in the environment and humans.

The largest release of HBCD in the life cycle are reported to be during the waste phase and the main fraction of HBCD containing waste is identified to be insulation products flame retarded with HBCD. The main waste stream containing HBCD will be waste EPS and XPS insulation materials in construction sector. As a process of rapid urbanization is underway in many Asia-Pacific countries, the building insulation market is quickly growing, and an increasing number of buildings with EPS and XPS insulation materials are being renovated or demolished, leaving behind a large amount of construction and demolition (C&D) waste containing HBCD. Since the use of HBCD in EPS and XPS and buildings continues, the stock of the HBCD contained EPS and XPS foam waste in buildings and constructions will be produced in the future. Therefore, it is necessary to promote the sound management of HBCD and ultimately eliminate the HBCD in thermal insulation materials from C&D waste.

To achieve the goal, a basic survey on the occurrence of HBCD in C&D waste, its current pollution control status should be conducted. This project "Sound management of HBCD in insulation materials and wastes generated from construction and demolition in Asia-Pacific countries" will be implemented to support Asia-Pacific countries in eliminating the HBCD in thermal insulation materials from C&D waste by providing information and recommendations. Under the project, researchers surveyed the historical and current production of HBCD and its usage in insulation materials in construction and demolition industry, and estimated the generation of HBCD containing in insulation waste in future 50 years. National management of HBCD in insulation materials and wastes, current treatment and disposal measures are investigated to analyze the challenges on HBCD elimination. Based on the challenges, researchers proposed some recommendations to help the government and industries to eliminate HBCD.

2. The historical and current use of HBCD in different types of insulation products in China

HBCD is one of the three most widely used brominated flame retardants in the world, following the usage of polybrominated diphenyl ethers (PBDEs) and Tetrabromobisphenol-A (TBBPA). With the ban of PBDEs (including the commercial penta- and octa- and Deca-brominated diphenyl ether formulations) in the world from the early 21st century, HBCD become typical substitute to replace PBDEs in products and its market demands continues to grow (Ueno et al, 2006; Li Lin et al, 2012).

HBCD was reported to be produced in China, Europe, Japan, and the USA and its main market share was in Europe and China. In 1999, the global production of HBCD was reported to be 15900 t. In 2001, it increase to 16 700 t, of which 9500 t (57%) was sold in Europe, 23% was sold in Asia (3900 t) (Covaci A et al, 2006; Gao et al, 2011). In 2006, the global production volume increased to 20000 t.

Now, Due to the rapid economic growth and the phase out progress of brominated frame retardants (BFR) in developed countries, China has become one of the largest BFR manufacturer and consumer. To promote the environmentally sound management of HBCD in Asia-pacific region, it becomes necessary to study the historical and current use of HBCD in China. In this part, production data of HBCD in China through literature review and experts consultation was got. Then combined with reasonable assumption, the historical production amount of HBCD and its usage in insulation materials in China in last decades was estimated.

2.1 The production and usage of HBCD in China

The practical volume of HBCD used in insulation materials contains the HBCD produced domestically (V_P) and the HBCD imported from other countries VI, except for the HBCD volume exported to other countries(V_E). As the following fomula:

$$V_U = V_P + V_I - V_E$$

For the production data of HBCD, relatively few studies have been conducted during the past decades. Before 2000, HBCD was not the primarily used BFR in China, no production data has been reported. From 2001-2005, the largest producer of HBCD at that time has produced a total of 6663 t of HBCD (XuanChang Tong et al, 2009). In 2007, the estimated domestic production volumes of HBCD was 7500 t (Yuqi Jiang et al, 2006) According to the Persistent Organic Pollutants Review Committee (POPRC) under the Stockholm Convention, the annual production of HBCD in China in 2009 and 2010 is approximately 9,000t to 10,000 t and 15,000 t (POPRC, 2011). In 2011, the global market demand for HBCD increased to 31,000 t. And China reported18,000 t of HBCD produced in 2011, which amounted to more than half of the global production (POPRC, 2011; POPRC, 2012). The HBCD production are intensively located in coastal areas in Shandong and Jiangsu province, where abundant bromine resources are distributed (Yawei Wang et al, 2010; Zhang Y et al, 2018).. Limited data shows there are 14 HBCD production plants in China before 2011 (Yi S et al, 2016). Table 1 concluded the accessible data on HBCD production in China during the past years.

Table 1 Reported HBCD production volume in China

Year	2001-2005	2007	2009	2010	2011
Production volume (tons)	≥6663*	7500	9500 (9000-10000)	15000	18000

*Note: It is only the largest producer of HBCD in China. The total production volume of HBCD in China was bigger than 6663.

Before 2000, HBCD was not primarily used in China. Therefore, it production and usage in insulation materials were out of consideration. In 2009, PBDEs was listed in the Annex A to the Stockholm Convention. Under the context, the production of HBCD kept rising to replace PBDEs. Considering 7500 t of HBCD was produced in 2007, we assume the average HBCD production volume was 8000 t/year during 2000-2009. From 2010, the demand for HBCD was greatly increased. Based on the known data, we assumed the average production volume of HBCD is 18000 t/year during 2010-2015. With HBCD being listed in the Stockholm Convention, the Chinese government announced the ban of HBCD production, use, import and export at the end of 2016. However, an exemption was given to the production, use, import and export of HBCD for EPS and XPS from 2016 to 2021 (Ministry of Environmental Protection of China, 2016). Li et al estimated the production volume of HBCD during 2016-2021, with an average of 8305 t/year (As shown in table 2).

Table 2 The estimated HBCD production volume during 2016-2021

Year	Production Volume (tons)

2016	20853.66
2017	16646.34
2018	12439.02
2019	8231.707
2020	4207.317
2021	0
Sum	41524.39
Average	8304.878

China has never imported HBCD as pure chemical nor formulation to China, and the export volume has declined since 2013 to almost zero by 2015 because an increasing number of previous importers have voluntarily restricted their HBCD trade (Li et al, 2016). In 2011, China reported to POPRC that about 5500-6000 t of HBCD (the total production amount 18000 t) was exported, with a rate of 33% (POPRC,2012). Assuming the average of export rate of HBCD during 2001-2015 keeps 33%. According to the assumption, we can calculate the total production volume of HBCD during 2001-2009, 20010-2015, 2016-2021, and related exported volume. Table 3 concluded the total production volume during 2000-2021.

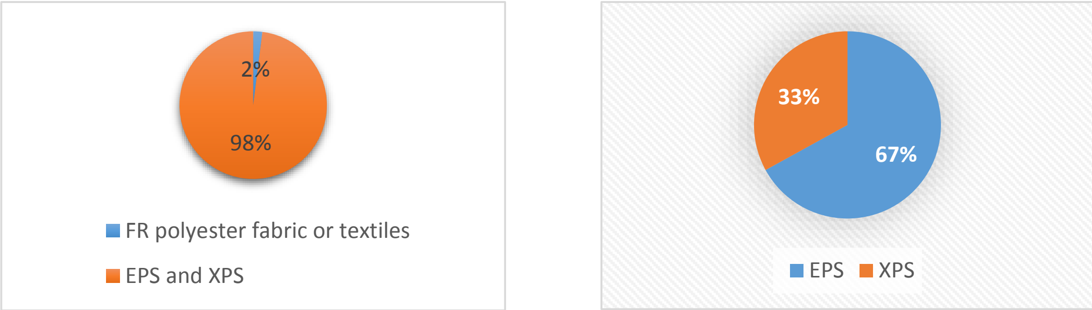
Table 3 The total production volume of HBCD during 2000-2021

Year	Production volume (tons)	Export volume (tons)	Practical usage volume (tons)
2001-2009	72000	23760	48240
2010-2015	108000	35640	72360
2016-2021	41525	0	41525
Sum	221525	59400	162125

As shown in table 3, during 2000-2021, China is estimated to produce a total of 221,525 t of HBCD, and exported 59,400 t of HBCD. Almost 162,125 t of HBCD are used in the industry.

2.2 HBCD in insulation materials

In China, HBCD has been used in two sectors to produce three major end-products. Before 2009, 2% of annual production of HBCD has been used in Flame Retarded polyester fabric or textiles, which has subsequently been almost completely replaced by other lower-priced flame retardants. The rest 98% has been used in EPS and XPS insulation boards which were used in external insulated composite systems (Li Li et al, 2016). From 2010, HBCD is assumed to be completely used for EPS and XPS insulation boards. In 2011, China reported to the Persistent Organic Pollutants Review Committee that it produced 18 000 tons of HBCD in 2011, of which 5500-6000 tons was exported, 9000 tons is used for EPS and 3000 tons for XPS (POPRC,2012). The data is consist with the assumption. In China, HBCD has not been used in furniture or virgin polystyrene packaging materials and high impact polystyrene (HIPS) in electrical and electronic equipment (Beijing Institute of Technology, 2011).



(1) The use of HBCD in China before 2010 (2) The current use of HBCD in China

Fig.2 The use of HBCD in China

The situation in China is different from some other countries (POPRC, 2011; Rani et al. 2014). Other literatures reported that about 90% of the HBCD in the world are used for EPS and XPS in building and construction industry (Climate and pollution Agency, 2010). Other minor uses (about 10%) is in textile applications and electric and electronic appliances (high impact polystyrene/HIPS).

During the past decades, China is undergoing a rapid process of urbanization. Due to the ever-increasing pursuit of both fire safety and energy efficiency in constructions field, the demands for flame retarded insulation materials are dramatically increased. China has regulated that, the combustion performance and flame retardant treatment of materials used in energy-saving buildings should comply with existing national standards/specifications. In 2005, the Ministry of Housing and Urban-Rural Development (MOHURD) issued "Code for Fire Protection Design of Tall Buildings" (GB50045-95), which classified non-combustion, hard-combustion and combustion components in buildings. In 2015, MOHURD issued “Code for fire protection design of buildings”(GB 50016-2014) , and abolished "Code for Fire Protection Design of Tall Buildings" . The Code provided the fire protection requirements when design different kinds of buildings, for example, plants, warehouses, storage yards, storage tanks, civil buildings, urban traffic tunnel etc. and regulated that the exterior wall of buildings should comply with relevant fireproof endurance rating.

In 2009, China issued the Temporary regulations for exterior insulation system and exterior decoration for civil buildings and defined four fire proof grades for the insulation materials based on fireproof endurance rating (FER): A, B_1, B_2 and B_3. FER A is for non-flammable materials, such as Rock wool, glass wool, foam glass, foam ceramics, foamed cement, hole-closed expanded perlite, and etc. FER B1 and B2 are materials difficult to be combustible, and FER B1 is more fire retardant than FER B2. Materials with FER B1 is difficult to catch fire in the air or be ignited under high temperature. Materials with FER B2 can retard flames to some extent, but in case of open fire or very high temperature, they are more easily burst into flames and spread to surrounding inflammable materials, such as wood, wooden frame, wooden beams or wooden stairs. Normally, materials with FER B1 and B2 can effectively prevent or slow down the fire spreading. The common used materials with FER B1 and B2 include flame retarded EPS, XPS, specially treated polyurethane (PU), polyethylene (PE), and etc. Materials with FER B3 is inflammable, which has great risk of fire ascendant. The Temporary regulations for exterior insulation system and exterior decoration for civil buildings required that Insulation materials used for building exterior wall need to be at least Grade B2.

EPS, XPS insulation boards are commonly used insulation materials for exterior walls. The HBCD content in EPS and XPS with different FER varies differently (Table 4) on the Chinese market. A market research in 2012 showed that about 90% of insulation boards are in FER of B2 (Peking University, 2012). The average HBCD contents in EPS/XPS on China's market are slightly higher than the global average loading (0.5% –0.7% for FR-EPS and 0.8%–2.5% for FR-XPS insulation boards) (Li et al, 2016; POPRC, 2011). Table 4 shows the HBCD content in EPS and XPS insulation boards with FER of B1 and B2.

Table 4 The HBCD content in EPS and XPS insulation boards with FER of B1 and B2

	FER of B2	FER of B1
HBCD content	0.7-0.9%	1.4%–1.8%

(by weight) in EPS		
HBCD content (by weight) in XPS	2%–2.5%	4%

Since few data on the production and usage amount of EPS/XPS insulation materials on Chinese market can be accessed, we will use the calculated practical usage amount of HBCD and its materials flow to estimate the production and usage amount of EPS and XPS insulation materials in China. Assuming no EPS and XPS insulation materials were imported in China.

1) The production amount of EPS and XPS insulation during 2000-2009

Assuming 90% of the EPS/XPS insulation boards are in FER of B2 and 10% are in FER of B1, according to the previous survey. For convenient estimation, we take the lowest value of the HBCD content range in EPS/XPS insulation boards (as shown in table 4) with different FER. In this way, we can get the possible highest volume of HBCD containing EPS/XPS materials and waste. Therefore, The HBCD content in EPS and XPS in FER of B2 are 0.7% and 2%, respectively, and in EPS and XPS in FER of B1 are 1.4% and 4% respectively.

Before 2009, 98% of HBCD were produced for EPS and XPS insulation materials, which means 47,275 tons were produced for EPS and XPS. And the HBCD used to produce EPS and XPS were 3:1 (based on the official data of 2011: 9000 tons is used for EPS and 3000 tons for XPS). As the practical HBCD usage amount in China is 48,240 tons, the HBCD used to produce EPS and XPS are calculated to be 35,465 and 11, 810 tons. Based on the assumption of the HBCD content in EPS/XPS insulation boards and the distribution rate of EPS/XPS insulation boards in FER B2 and B1, we calculated the total amount of the EPS and XPS insulation boards are 4,605,844 tons and 536,818 tons. Among which, EPS and XPS with FER of B2 are 4,145,260 and

483,136 tons respectively, EPS and XPS with FER of B1 are 460,584 and 53,682 respectively. Table 5 lists the calculation results.

Table 5 The production amount of EPS/XPS insulation boards during 2001-2009

EPS		XPS	
EPS in FER B2 (tons)	EPS in FER B1 (tons)	XPS in FER B2 (tons)	XPS in FER B1 (tons)
4,145,260	483,136	460,584	53,682

2) The production amount of EPS and XPS insulation during 2010-2021

During 2010-2021, HBCD is assumed to be completely used for EPS and XPS insulation boards. Still, the HBCD used to produce EPS and XPS were 3:1, and The HBCD content in EPS and XPS in FER of B2 are 0.7% and 2%, respectively, and in EPS and XPS in FER of B1 are 1.4% and 4% respectively. As the practical HBCD usage amount in China is 113,885 tons, the HBCD used to produce EPS and XPS are calculated to be 85,414 and 28,471 tons. The total amount of the EPS and XPS insulation boards are 11,092,727 tons and 1,294,136 tons. Among which, EPS and XPS with FER of B2 are 9,983,454 and 1,164,722 tons respectively, EPS and XPS with FER of B1 are 1,109,273 and 129,414 respectively. Table 6 lists the calculation results.

Table 6 The estimated production amount of EPS/XPS insulation boards during 2010-2021

EPS	XPS

EPS in FER B2 (tons)	EPS in FER B1 (tons)	XPS in FER B2 (tons)	XPS in FER B1 (tons)
9,983,454	1,109,273	1,164,722	129,414

3) The historical and current use of HBCD in insulation products in China

As calculated, during 2000-2021, China is estimated to produce 221,525 tons, with 59,400 tons exported and 162,125 tons used domestically. Before 2000, HBCD is not the primarily used flame retardants in China and its production is not considered in this report. After 2021, the production, import and export of HBCD will be closed without any exemption. Based on the data, the insulation products used HBCD as flame retardants are calculated. A total of 17 million tons (17,529,525) of flame-retarded polystyrene insulation boards are estimated to be used, including 15.7 million tons (15,698,571) EPS and 1.8 million tons (1,830,954) XPS.

3. The generation trends of insulation wastes containing HBCD in the next 50 years

3.1 Construction and demolition (C&D) waste in China

Construction and demolition (C&D) waste is defined as “the waste produced during new construction, renovation, and demolition of buildings and structures” (Kofoworola et al, 2009). The construction industry generates approximately 35% of industrial waste in the world (Solís-Guzmán et al, 2009). Due to an increased demand for housing and infrastructure and rapid growth of towns and cities, the amount of generated waste has been increasing in most of the countries. The rising levels of waste generation, increasing unregulated and illegal dumping of C&D waste, and the scarcity of landfill space has become critical issues in many countries.

In China, with the rapid urbanization, the building industry has contributed to 26.7% of the national GDP (Zheng et al, 2017). In 2011, the annual output of the construction industry was approximately US $2.1 trillion, and about 43.11 million people, accounting for more than 5% of the total labor force were employed in the industry (Duan huabo et al, 2015). Associated with the rapid development of construction industry, a large amount of C&D waste are produced, which is estimated to be the around 8 times larger than municipal solid waste (MSW)(Yuan H, et al, 2011) and becomes one of the largest solid waste streams in China. C&D waste has large quantities and complex compositions. It mainly consists of concrete, wood, metals, plasterboard, cardboard, plastics, asphalt, and mixed site debris such as soil and rocks. 80% of the waste has the potential to be reused (Zheng et al, 2017). While, the C&D waste also contains hazardous matters such as asbestos, heavy metals s (e.g., As, Pb, Hg, Cr, Cd, Cu, and Zn), persistent organic compounds (poly Brominated Diphenyl, e.g., PBDEs, HBCD), and volatile organic compounds (Zheng et al, 2017; Duan et al, 2015).The C&D waste brings great potential risk to the environment, regional ecological security and sustainable development.

C&D waste are normally grouped by construction waste, demolition waste and decoration waste. The volume and type of materials produced by construction versus demolition can differ greatly [8]. The demolition projects often produce more than 10 times as much waste material per square meter as construction projects. Construction waste normally contains more modern building materials which than demolition waste since new buildings are rarely torn down. Demolition waste is often contaminated with paint, adhesives, and dirt. Almost all the insulation materials containing HBCD generated from demolition waste.

Two reports has roughly estimated the total C&D waste generation in China. The Annual Report of the Comprehensive Utilization of Resources in China (2014) claimed that around one billion tons of C&D waste were generated in China in 2013 (NDRC, 2014). The volume is equal to the total C&D waste generation in the entire European Union (EU, 25 counties)(Brito et al,2013) and six times higher than that of the US.

China Strategic Alliance of Technological Innovation for Construction Waste Recycling Industry (CSATICRI, 2014) reported that the total amount of C&D waste is approximately 1.5 billion to 2.4 billion annually in China, and the recycling rate is less than 5%. Due to the two reports are extremely unreliable since there is neither official public statistics nor clearly explained methodology to support these C&D waste generation estimates, Zheng et al from Shenzhen University provided an explicit analysis to estimate the C&D waste volume based on a weight-per-construction area method. According to the research, approximately 2.36 billion tons of C&D waste were generated in China annually during the period of 2003–2013, of which demolition waste and construction waste contributed to 97% and 3%, respectively, in 2013. The data is higher than the previous two reports.

The C&D waste varies in different region of China. Table 6 represents the distribution of C&D waste in 2013 in China. East China contributed to 56% of total C&D waste in China in 2013, followed by Middle China (21%) and South China (11%). The reason may be that these three regions are the fastest growing regions of China with a rapid economic development and city expansions. For instance, the construction industry of these three regions accounted for 64.3% of total GDP of China's construction sector in 2013 (NBSC, 2014).

Table 7 The distribution of C&D waste in 2013 in China

Region	North China	Northeast China	East China	Middle China	South China
C&D waste (%)	4%	4%	56%	21%	11%

3.2 Insulation wastes containing HBCD in China

For the composition of C&D waste, it includes inert (concrete, brick, concrete block, uncontaminated soil, rock, and gravel) and non-inert (organic, polymer or contaminated materials, such as furniture and PUR foam insulation) substances (Defined by official document). The four inert wastes (i.e., concrete, mortar, brick/block, and ceramic) accounted for 87% of the total amount (Zheng et al, 2017). Compared to developed countries, the share of scrap metals in China is higher. So far, very few studies attempted to quantify the HBCD substance in C&D wastes or their components. Li et al. (2016) conducted a scenario-based dynamic substance flow analysis, coupled with interval linear programming, and forecast future HBCD emissions in China. They only pointed out that during the demolition process C&D waste is manually sorted and crushed on site at destruction sites, and polystyrene C&D materials are separated out from other inert C&D waste such as bricks and concrete. Original HBCD constituent in C&D waste is released into the atmosphere during these sorting and crushing operations, and is assumed to contribute 10% of the atmospheric emissions in the demolition process. Li′s study warns of the huge challenges that China could face in attempting to eliminate HBCD contamination in the coming decades.

Since no specific data on the HBCD content in C&D waste, we can only estimate the insulation waste containing HBCD from C&D waste in term of the generation source. As we estimated, HBCD production will be closed no later than 2021, and a total of 17 million tons EPS/XPS insulation material using HBCD as flame retardants will be produced in China. According to the General rule for architectural design of civil buildings, general constructions or building will stand up for 50-100 years. While, due to the urbanization progress and massive demolition projects, the average lifespan of buildings in China are no more than 35 years. Therefore, it is reasonable that in future 50 years, all the produced HBCD contained EPS/XPS insulation material will be wasted. Considering the EPS/XPS insulation waste will be mixed in the C&D waste, the practical EPS/XPS insulation waste will much higher than the 17 million (EPS/XPS insulation materials volume).

4. National management of HBCD in insulation materials and waste generated

from construction and demolition

4.1 The management of HBCD

In 25th October, 2016, China approved the Amendment to Annex A to the Stockholm Convention to list HBCD with specific exemptions. According to the notice, China banned the production, usage and import/export of HBCD from 26th December, 2016, except the exemptions for its use in insulation boards in construction field[1]. The exemptions will last five years and be ended in 25th December, 2021. Later on 30th December, HBCD noticed to list in The Inventory of Toxic Chemicals Strictly Restricted Importing/Exporting (2014)[2], enterprises import/export the substance should registered in the Ministry of Environment Protection (MEP) and comply with the exemptions from January 1st 2017.

From 2011, the government began to implement Reporting Mechanism of Persistent Organic Pollutants in China to obtain the basic information on production, usage, and emission of POPs. HBCD and PFOS have been covered by the Mechanism in 2015, related enterprises and facilities should report required information and data to MEP. HBCD has also been listed in the 2015 Inventory of Hazardous Chemical in China. Enterprises and facilities involved in the production, storage, sales and uses of HBCD should comply with safety management requirements under Regulation on Safety Management of Hazardous Chemicals.

On December 28, 2017, Chinese Ministry of Environmental Protection (MEP) published on its official website the Catalogue of Priority Chemicals (1st Batch)[3]. A total of 22 chemicals include HBCD were listed in the catalogue. As it regulated, risk control measures on these chemicals should be taken to minimize the hazard of the chemicals' production and use on human health and the environment. The risk control measures include:

1) Permit system for discharge pollutants: enterprises discharge air/water

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1 http://www.zhb.gov.cn/gkml/hbb/bgg/201701/t20170103_393822.htm
2 http://www.zhb.gov.cn/gkml/hbb/bgg/201312/t20131231_265886.htm
3 http://www.zhb.gov.cn/gkml/hbb/bgg/201712/t20171229_428832.htm

pollutants should apply discharge permissions as required and keep monitoring the presence of pollutant in the surrounding environment.

2) Restriction measures: to revise national mandatory standards, restricting the use of chemicals in certain products; to list the chemicals in specific catalogue, encouraging and promoting the substitution.

3) Cleaner Production Assessment and information disclosure: Enterprises use toxic materials in production process or discharge toxic waste should conduct Cleaner Production Assessment and disclose relevant information for the public according to specific regulations.

4.2 The management of EPS/XPS Insulation materials in construction and building sector

In China, the fireproof endurance rating of insulation materials in construction and building sector are classified as Grade A, B1, B2, B3 (see chapter 2.2). National standard GB/T 10801 “Moulded polystyrene foam board for thermal insulation” defines the classification, requirements, test methods for polystyrene foams and its label, package, transfer and storage requirements. It includes two parts, GB/T 10801.1 for EPS and GB/T 10801.2 for XPS. The standard regulated that the oxygen index of the products should no less than 30% and FER should reach at least grade B2.

4.3 The management of waste generated from construction and demolition

China has preliminarily established a framework of solid waste management laws and regulations system. Under the “Law of the People's Republic of China on the Prevention and Control of Environmental Pollution by Solid Waste” (revision in 2004), a series of national regulations, department regulations and guides have been promulgated. For C&D waste, China issued a series ministerial decree, including Regulation on the Municipal Construction & demolition Waste Management, Notice on the Division of

Management Responsibility and Obligation on the Recycling of C&D waste, Technical Guidelines on the Treatment of C&D Waste in Earthquake Disaster Region. In 2009, China published Technical Code for Construction and Demolition Waste Treatment (CJJ 134-2009) in 2009, provided general requirements for the collection, transit, transfer/distribution, recycling, backfill and landfill. Firstly, the waste amount should be reduced at source, collected after sorting by different types, and reused or recycled on site. Recycled aggregate concrete, bricks and blocks, asphalt should comply with relative products standards. Two disposal measures-backfill and landfill are listed in the technical code. No requirements on the issue of hazardous components in the C&D waste. Actually, on the national level, there is no specific regulations on sorting and safe treatment measures for non-inert or hazardous C&D waste components, such as the asbestos, brominated flame retardant thermal insulation material, and lead paint debris used in old buildings.

On the contrary, some developed countries has established effective management and industrialization model. For example, in the United States, the hazardous waste from C&D waste is well managed under the Resource Conservation and Recovery Act (RCRA). In Germany, C&D waste management has been taken into full consideration for several decades, and many initiatives have been in place, at both the state and the local level. Germany has released more than 180 laws and regulations related to a waste disposal since 1970s, and till 2012, its recycling rate of C&D waste has reached 68%. (Duan et al, 2016).

China needs to improve the legal system of C&D waste. Since 2013, promoting the recycling and reutilization of C&D waste has become one of ten Key Tasks according to the Action Plan of Green Construction Industry. The government requires relevant departments to promote the centralized treatment and classified utilization, accelerate the development of recycling and reutilization technology and equipments, and the conduct pilot projects of C&D waste recycling and reutilization, and establish labeling mechanism for products made of recycled materials. Local governments are encouraged to build C&D waste treatment base. Accordingly, some cities in China such as Beijing, Shanghai, Shenzhen, Tianjin has done some attempts to draw up specific regulations on the recycling and reutilization of C&D waste.

5. The recycling and disposal of insulation materials waste containing HBCD from C&D in china

5.1 The recycling and disposal for insulation waste containing HBCD generated from C&D in China

(1) The recycling and disposal of C&D waste

In China, there are around five approaches to dispose of mixed C&D waste: dumping, landfilling, on-site incineration or burning, mixing it into MSW for disposal (incineration or landfill), recycling or reuse. Generally, the recycling of the C&D waste in China are mainly on the recycling of high value materials, such as waste metals, steel bars, sorted timbers etc. Some reusable parts of C&D waste such doors and windows, etc. are also separated and sold as second hand construction materials in building sites. Other waste such as concrete debris and bricks are considered with mixed C&D waste. Some mixed C&D waste are disposed of as fill material or used to produce concrete blocks, while, the massive parts are sent to landfill or dumping sites.

In China, the recycling part only accounted for 10% of the C&D waste generated. For the past few decades, some building owners, demolition contractors, and waste haulers disposed of this waste improperly and illegally at dumping sites to avoid transportation costs and landfilling fees at waste disposal facilities. Dumping sites have been discovered in gravel pits and ground water recharge areas, on farm land, on prime residential property, in borrow pits, and in low lying areas [3,12]. In recent ten years, some formal landfills and public filling areas are built to provide a convenient and cost-effective solution to disposal waste generated in construction industry. Some data (Yu Yi, 2016) shows that, China has established 870 dumping or disposal sites for C&D waste, which is distributed in 18 provinces. Among these site, 90% are for simply dumping, and 10% equipped with recycling and treatment measures. Fig.3 shows the life cycle flow of C&D waste in China.

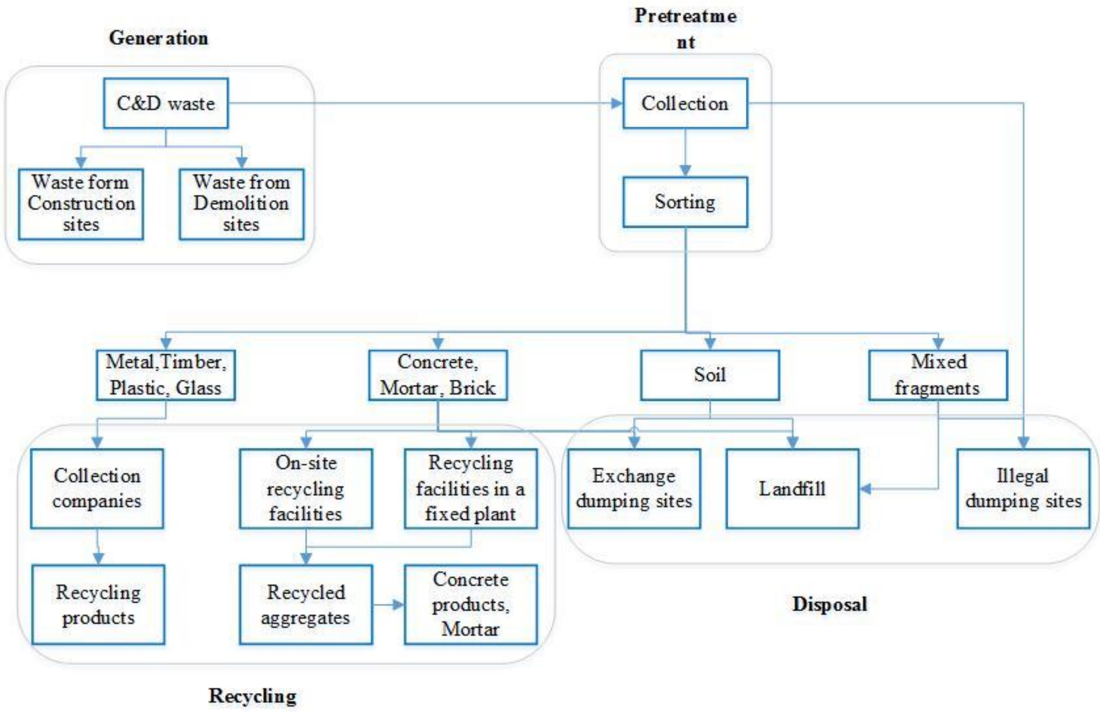

Figure 3 Life cycle flow of C&D waste in China

For many cities in China, the waste volume and types varies greatly, and its material recovery/ recycling, dumping/landfill practices are developed in different stage. For some big/developed cities, such as Beijing, Shanghai, Shenzhen, the quantity of treated C&D waste and the landfill rate are much higher than other cities. Due to the limited landfill disposal capacity and high cost of land resource in big cities, it is not unusual C&D waste is transferred to less-developed neighboring regions (Zheng et al, 2017). Table 8 Landfill sites for C&D waste in some big cities of China in 2011- 2013(Duan Huabo et al, 2015). As can be seen from the table, Beijing, Shanghai, Shenzhen, Tianjin represent better management and more formal treatment of C&D waste. It also shows the trend of formal management of C&D waste in China, as the landfill site are greatly increased from 2011 to 2013.

Table 8 Landfill sites for C&D waste in some big cities of China in 2013

Cities	Population	Landfill Sites	Quantity	Landfill rate

	Million			(Million tons)	(%)
	2013	2010	2013	2013	2013
Beijing	19	4	25	35	74%
Shanghai	22	-	-	86	70-80%
Chongqing	29	15	29	15	-
Shenzhen	10	2	3	50-60	-
Guangzhou	11	-	-	40	52%
Tianjin	11	-	-	6	95%
Wuhan	9	0	3-6	50	35%
Chengdu	7	-	-	128	-
Xi’an	7	3	18	39-37	-
Changsha	4	0	3-5	16	-
Zhengzhou	4	0	0	16-20	0
Taiyuan	3	4	16	15	67%

Compared to developed countries, where C&D waste usually ends up in C&D waste landfills after separation and recycling [11, duan 2015], China still work to improve the sound recycling and treatment practice of C&D waste. The recycling rate in China is relatively low compared to many developed countries. The EU-28 has a recycling rate between less than10% and over 90% (from Eurostat, 94% for the Netherland by, 87%

for the UK, 76% for Italy, and 34% for Germany), which is comparable to U.S (70%), and Japan (95%)).

2) The recycling and treatment for insulation waste containing HBCD generated from C&D in China

In China, the composition of demolition waste are closely related to the building types, for example, civil buildings, industrial buildings, which have different structures. The National Bureau of Statistics of China provides information on the composition of demolition waste of building with different structures in China. As shown in table 8, the Burea defines 3 kinds of building structures, including brick-concrete structure, frame structure, and frame-shear wall structure, and classed 8 kinds of waste compositions, including bricks, concrete, pile head, package materials, roofing materials, steels, woods and others. Insulation materials are contained in others and not listed separately.

Table 8 The composition of demolition waste of building with different structures in China[i]

Compositions	Proportion (%)		
	Brick-concrete structure	Frame structure	Frame-shear wall structure
Bricks	30-50	15-30	10-20
Concrete	6-15	10-20	10-20
Pile head	8-15	15-30	15-35
Package materials	--	8-15	8-20

Roofing materials	5-15	5-20	10-15
Steels	2-15	2-5	2-5
Woods	1-5	1-5	1-5
Others	10-20	10-20	10-20
Total	100	100	100

Currently, C&D waste has not been sorted managed. As described in Chapter 5.1, on demolition sites, only high value materials, such as waste metals, steel bars, sorted timbers are collected and recycled. Some reusable parts of C&D waste such as doors and windows, etc. are separated and sold as second hand construction materials in building sites. Other waste such as concrete debris and bricks are considered as mixed C&D waste. Most mixed C&D waste are landfilled on sites or sent to dumping sites. Insulation waste containing HBCD from C&D waste are not separated from the waste stream. They are mixed with other wastes, being sent to landfill.

5.2 The existing control schemes for the recycling and disposal of insulation materials containing HBCD

Currently, there is no formal control scheme for recycling and disposal of waste insulation materials containing HBCD in China. Waste insulation materials containing HBCD are not identified, and separated out from the main waste stream. While, on the issue of HBCD in C&D waste, some studies has been conducted in research field. In 2016, Duan et al tested the HBCD content in some C&D waste samples, including asphalt (pavement), textiles, insulating foam materials, furniture and plastic materials (Duan et al, 2016). Extremely high concentrations of total HBCD (the sum of the three individual isomers, α-HBCD, β-HBCD and γ-HBCD) were found in the scrap foams-7039.00 μg/kg, and relatively high concentrations of 30.02 μg/kg were found in furniture samples. In other organic C&D wastes, the HBCD concentrations were rather low, ranging from 3.18 to 10.90 μg/kg. It is clear that the HBCD amount in C&D wastes, particularly in organic mixtures can't be overlooked, and that scrap foam materials should first be separated out from other C&D wastes at the source, before further processing.

6. Recommendations

As for now, the effective C&D waste sorting, recycling and disposal management system has not been established in China. Due to the insufficient information of generation characteristics, composition and environment implications evaluation of C&D waste, it is difficult to build reasonable disposal strategy and choose appropriate resource recovery technology. The government is recommended to guide the research of the basic information of C&D waste firstly, and then technologies to separate the HBCD contained C&D waste should be developed by the industry. Awareness on the risks of C&D waste should be delivered to the industry and public.

The specific recommendations are proposed as followed:

(1) To conduct research on the production, variation tendency, flowing direction, environmental pollution features for the C&D waste, to figure out the occurrence and distributions of the main hazardous components of different kinds of C&D waste, especially heavy metals and organic pollutants such as HBCD, PBDEs, etc., tracking its sources and analyzing the emission and treatment (such as extracting, incineration, etc.) character. Based on the scientific information, the government and the industry can accordingly establish applicable management systems or technical methods.

(2) Based on the clear information on C&D waste and its environmental risks, the government should establish and implement supporting legislations, national

standards and incentive measures, to promote the hazardous components reduction on the source and the life-cycle process, and to improve the recycling and recovery efficiency.

(3) The industry should promote the development of advanced and environmentally sound technology and equipment on recycling/recovery, treatment and final disposal, to support the enforcement of the legislation and the practical recycling and treatment of C&D waste. It is recommended to use C&D waste to produce recycled products, such as aggregates, bricks etc., which can reduce resource consumption and also reduce the soil occupation which is needed for final landfill.

(4) Specially, for HBCD-containing C&D waste, it is recommended to separate it from the waste stream firstly before the treatment and disposal. Li et al (2016) found that while production will end in around 2021, the emissions of HBCD will continue until after 2100, 44% of which arise from current manufacture of HBCD-containing end-products with a further 49% from end-of-life disposal of HBCD-containing waste. He recommended that the most effective end-of-life emission control option is a pre-demolition screening combined with incineration.

References

Climate and pollution Agency, 2010, Exploration of managements options for HBCD, Report to the 8th meeting of the UNECE Task Force on Persistent Organic Pollutants, Montreal 18-20 May 2010

Covaci A1, Gerecke AC, et al. Hexabromocyclododecanes (HBCDs) in the environment and humans: a review. Environ Sci Technol. 2006 Jun 15;40(12):3679-88.

Ueno D, Alaee M, Marvin C, et al. Distribution and transportability of hexabromocyclododecane (HBCD) in the Asia-Pacific region using skipjack tuna as a bioindicator[J]. Environmental Pollution, 2006, 144(1): 238-247.

Li Lin. Oxidative damage of exposure to HBCD and composite exposure to HBCD and PBDEs on the new-born rats of brain development(in Chinese)[D], Donghua University, 2012.

Covaci A, Gerecke A C, Law R J, et al. Hexabromocyclododecanes (HBCDs) in the environment and humans: a review[J]. Environmental science & technology, 2006, 40(12): 3679-3688.

Gao S, Wang J, Yu Z, et al. Hexabromocyclododecanes in surface soils from e-waste recycling areas and industrial areas in South China: concentrations, diastereoisomer-and enantiomer-specific profiles, and inventory[J]. Environmental science & technology, 2011, 45(6): 2093-2099.

XuanChang Ton, et al. New challenges facing China on the management of SCCP and HBCD [C], 2009.

Yuqi Jiang. The current status and development trends of brominated flame retardants [J] (in Chinese), Chemical Industry, 2006, 24(9):14-18.

POPRC, 2011. Report of the Persistent Organic Pollutants Review Committee on the Work of Its Seventh Meeting: Risk Management Evaluation on Hexabromocyclododecane.UNEP/POPS/POPRC.7/19/Add.1.

POPRC, 2012. Report of the Persistent Organic Pollutants Review Committee on the Work of Its Eighth Meeting: Addendum to the Risk Management Evaluation on Hexabromocyclododecane. UNEP/POPS/POPRC.8/16/Add.3.

Yawei Wang et al. New research progress of the Stockholm Convention on Persistent Organic Pollutants [J] (in Chinese). Science China, 2010(2):99-123.

Zhang Y, Lu Y, Wang P, et al. Transport of Hexabromocyclododecane (HBCD) into the soil, water and sediment from a large producer in China[J]. Science of The Total Environment, 2018, 610: 94-100.

Yi S, Liu J G, Jin J, et al. Assessment of the occupational and environmental risks of hexabromocyclododecane (HBCD) in China[J]. Chemosphere, 2016, 150: 431-437.

Li L, Weber R, Liu J, et al. Long-term emissions of hexabromocyclododecane as a chemical of concern in products in China[J]. Environment international, 2016, 91: 291-300.

Beijing Institute of Technology, 2011. Survey Report on Basic Information of HBCDD in China. China's National Laboratory of Flame Retardant Materials, Beijing Institute of Technology, Beijing.

O.F. Kofoworola, S.H. Gheewala, Estimation of construction waste generation and management in Thailand, Waste management. 29 (2009) 731-738.

J. Solís-Guzmán, J., M. Marrero, M.V. Montes-Delgado, A. Ramírez-de-Arellano, A Spanish model for quantification and management of construction waste, Waste Management. 29 (2009) 2542-2548

H. Duan, J. Wang, Q. Huang, Encouraging the environmentally sound management of C&D waste in China: an integrative review and research agenda, Renew Sust. Energ. Rev. 43 (2015) 611–620.

National Development and Reform Comission (NDRC), 2014. Annual report of the comprehensive utilization of resources in China (2014).

J. de Brito, N. Saikia, Construction and demolition waste aggregates, Recycled Aggregate Concr. (2013) 81–113.

China Strategic Alliance of Technological Innovation for Construction Waste

Recycling Industry (CSATICRI), 2014. China construction and demolitition waste recycling industry development report 2014.

H. Duan, D. Yu, J. Zuo, B. Yang, Y. Zhang, Yong. Niu, Characterization of brominated flame retardants in construction and demolition waste components: HBCD and PBDEs, Sci. Total Environ. 572 (2016) 77–85.

F. Mendoza, J. Altabella, A. Izquierdo, Application of inert wastes in the construction, operation and closure of landfills: calculation tool, Waste Manage. 59 (2017) 276–285.

Zheng L, Wu H, Zhang H, et al. Characterizing the generation and flows of construction and demolition waste in China[J]. Construction & Building Materials, 2017, 136:405-413.

PART II :

HBCD in insulation products and wastes from construction and demolition in Vietnam

TABLE OF CONTENTS

ABBREVIATIONS

BDP	Bisphenol A bis (biphenyl phosphate)
BFR	Brominated flame retardants
DBDPE	Decabromodiphenylethane
HBCD	Hexabromocyclododecanes
HFR	Halogenated flame retardants
EPS	Expanded polystyrene
XPS	Extruded polystyrene
HIPS	High impact polystyrene
PCB	Polychlorinated biphenyl
PBDE	Polybrominated diphenyl ethers
POP	Persistent Organic Pollutants
TBCO	1,2,5,6-tetrabromocyclo-octane
TPP	Triphenyl phosphate

I. GENERAL INFORMATION ON HEXABROMOCYCLODODECANE

1.1. Introdution of HBCD

Hexabromocyclododecanes (HBCD) has been listed in Annex A of the Stockholm Convention in Decision SC-6/13.

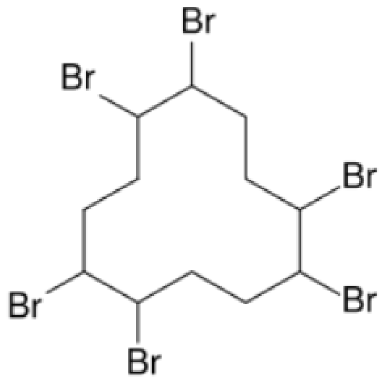

Figure 1. Structural formula of HBCD

The molecular formula of the compound is $C_{12}H_{18}Br_6$ and its molecular weight is 641 g/mol, commercially available HBCD is a white solid substance. its structure consists of 3 benzene rings and six bromine atoms. HBCD is lipophilic, has a high affinity to particles and low water solubility.

HBCD has a strong potential of bioaccumulation and bio-magnification. HBCD is persistent in air and is subject to long-range transport. HBCD is very toxic to aquatic organisms. HBCD toxicity to the nervous system and development for susceptible people has been observed[1].

1.2. Overview of production, use and releases of HBCD in the world

Production, trade of HBCD

According to the Bromine Science and Environment Forum (BSEF), HBCD is produced in the United States of America, Europe, and Asia. There is information available about suppliers and producers in China, but information on amounts of HBCD imported or produced in China is not available. More than half of the market volume was used in Europe. Total global demand for HBCD increased over 28% by 2002 to 21,447 tonnes, and rose again slightly in 2003 to

[1] Stockholm Convention, Hexabromocyclododecane –Risk profile, 2010

21,951 tonnes[2].

Table 1. Global demand of HBCD in 2001 in different regions of the world[3]

Unit: Ton

Global demand	US	Europe	Asia	Rest of the world	Total
2001	2,800	9,500	3,900	500	16,500

In the US EPA assessment, the sum of manufactured and imported HBCD is reported to lie between 4,540 tons to 22,900 tons in 2005[4].

The authorities in Japan have reported the sum of manufactured and imported HBCD to be 2,744 tonnes in 2008. The consumption in Japan reached 700 tonnes/year in the beginning of the 1990s[5], and has increased approximately four times since then.

The demand in 2006 in EU represents an increase of 22 % from 2001. The total volume of HBCD used in the EU was estimated to be about 11,580 tonnes in 2006. The demand of HBCD within the EU is bigger than the production and a net import to the EU was expected to have been around 6,000 tonnes in 2006[6]. The import of HBCD to EU is mainly from USA[7]. HBCD powder or pellets, master batch of HBCD, EPS beads, impregnated granules of XPS and high impact polystyrene (HIPS) pellets are often exported and imported downstream in the production chain for the manufacturing of end-products for further professional use or sales to consumers

In Canada 100,000 to 1,000,000 tons were imported into the country in the year

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[2] Bromine Science and Environmental Forum (BSEF). About Hexabromocyclododecane (HBCD). See http://www.bsef.com/our-substances/hbcd/about-hbcd/ (accessed Jan 2008). 2006

[3] Stockholm Convention, HEXABROMOCYCLODODECANE -DRAFT RISK PROFILE, 2010

[4] US Environmental Protection Agency (US EPA). Initial Risk-Based Prioritization of High Production Volume Chemicals. Chemical/Category: Hexabromocyclododecane (HBCD). Risk-Based Prioritization Document 3/18/2008

[5] Managaki S, Miyake Y, Yokoyama Y, Hondo H, Masunaga S, Nakai S, Kobayashi T, Kameya T, Kimura A, Nakarai T, Oka Y, Otani H and Miyake A. Emission load of hexabromocyclododecane in Japan based on the substance flow analysis. 2009.

[6] European Chemicals Agency (ECHA). Data on manufacture, import, export, uses and releases of HBCDD as well as information on potential alternatives to its use. 2008a,108 pp.

[7] Organization for Economic Co-operation and Development (OECD). SIDS Initial Assessment Profile for Cas. No. 25637-99-4, 3194-55-6, Hexabromocyclododecane (HBCDD). SIAM 24, 19-20 April 2007

of 2000, both as a pure compound and in products[8].

Several national authorities reported import of HBCD as a pure compound or in products; Canada (100-1,000 tonnes), Australia (<100 tonnes), Poland (500 tonnes imported from China annually), Romania (185 tonnes) and Ukraine.

The Australian authorities reported an import of less than 100 tons of HBCD each year. Ukraine reported an import of HBCD for use in cellular polystyrene products[9].

The amount HBCD in impregnated granules used in production of XPS and EPS is reported to be 185 tons by the Romanian authorities. Romania does not produce HBCD[10].

HBCD use

HBCD is used as a flame retardant additive, providing fire protection during the service life of vehicles, buildings or articles, as well as protection while stored. The use in the production of flame-retarded polystyrene materials began in the 1980s. The main application of HBCD is in polystyrene foam that is used in insulation boards, which are widely used in the building and construction industry. They exist in two forms, as expanded polystyrene (EPS) and extruded polystyrene (XPS) foams with HBCD concentrations averaging 0.7%. The second most important application is in polymer dispersion on cotton or cotton mixed with synthetic blends, in the back-coating of textiles where HBCD can be present in concentrations ranging from 2.2 – 4.3%[11]. A further smaller application of HBCD is in high impact polystyrene which is used in electrical and electronic equipment and appliances at levels ranging from 1 – 7%[12]. HBCD may also be added to latex binders, adhesives and paints. The use of HBCD in EPS in packaging material is believed to be very small. Another use of HBCD is in textile coating agents, mainly in upholstery fabrics, but also in bed mattress

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[8] Stockholm Convention, HEXABROMOCYCLODODECANE -DRAFT RISK PROFILE, 2010

[9] Stockholm Convention, Hexabromocyclododecane –Risk Profile, 2010

[10] Stockholm Convention, Hexabromocyclododecane –Risk Profile, 2010

[11] Kajiwara N, Sueoka M, Ohiwa T, Takigami H. Determination of flame-retardant hexabromocyclododecane diastereomers in textiles. Chemosphere. 2009;74(11):1485-9.

[12] European Chemicals Agency (ECHA). Data on manufacture, import, export, uses and releases of HBCDD as well as information on potential alternatives to its use. 2008a,108 pp

ticking, upholstery in residential and commercial furniture, vehicle seating upholstery, draperies and wall coverings, interior textiles (roller blinds) and automobile interior textiles.

HBCD releases

Some Parties have studied HBCD releases to the environment such as: In Japan in 2000 the largest releases were found to be to air (571 kg/year) and water (41 kg/year). The total releases to the environment are increasing in Japan, In Japan atmospheric emissions of HBCD from textile coating in the industry accounts for more than half of the total releases from 1985 to 2011. In EU, the releases to water were the largest (releases to air were 665 kg/year, releases to waste water were 1,553 kg/year, releases to surface water were 925 kg/year). In EU the total releases from insulation boards (1,627.9 kg/year) represent more than half of the total releases (3,142 kg/year) in 2006. Total releases of HBCD from manufacture and use of insulation boards (1,627.9 kg/year) and manufacture and use of textiles (1,498.2 kg/year) are of the same magnitude table. Total releases from manufacture and use of electronic devices are minor (12.6 kg/year). In Switzerland one half of the releases are estimated to come from diffuse atmospheric emissions from installed EPS and XPS insulations boards. Losses to soil were considered to be minor in Japan, Switzerland and EU since waste with HBCD was disposed off in controlled landfills or incinerated.

However, due to uncontrolled landfills in Vietnam, HBCD will be released to the environment. Therefore, HBCD should be monitored and assessed in soil, water and air at landfill sites. The significance of those sources depends however on the waste management strategies chosen in the country, if the wastes are incinerated, or disposed of to an uncontrolled or controlled landfill. The overall figures of municipal waste within the EU from 2006 are that 68% goes to landfill and 32% is incinerated.

II. PRELIMINARY INFORMATION ON HBCD IN VIETNAM

Currently, information on the production, import, use, disposal of HBCD, HBCD containing materials, products in Vietnam is very limited. Project/task on assessment, identifying and inventory of production, import, use, disposal of HBCD has not carried out in Vietnam. However, based on information relating to the production, use and import of HBCD published by the Stockholm Convention on Persistent Organic Pollutants, and other Parties, and result of studies conducted by national and international expert groups in some locations in Vietnam, this report will provide initial information on HBCD aiming to orient management activities related to HBCD in Vietnam.

2.1. Situation of production, import and use of HBCD in Vietnam

Currently, there is no information on production of HBCD in Vietnam. However, according to documents on HBCD published by the Stockholm convention, HBCD-containing products may be used in Vietnam.

The main uses of HBCD globally are in expanded and extruded polystyrene foam insulation. There is some information about production and use of XPS and EPS in Vietnam as follow:

+ XPS is sound insulation material used in building construction. Advantages properties of WPS are sound insulation, thermal insulation. For that reason, XPS is used as a structure layer in wooden doors, plastic doors, freezing doors, steel railway ...

+ Use of XPS foam in concave insulation roofs: The structure of the concave insulation roofs has XPS layer at the top of the waterproofing roof to prevent the waterproofing layer from being damaged by temperature difference, ultraviolet radiation or human activities. It is not only a thermal insulation material but also a long-term anti - leakage material. The concave insulation roof can be used in renovating the roofs of old buildings by placing XPS from directly into the roof as an insulating material.

+ XPS foam used as thermal insulation in building: XPS foam is not only thermal insulation materials for various structural walls, but also enhancing the durability of the wall. In addition, XPS foam is used to decorate the wall, makes the surface wall smooth. Meanwhile, XPS foam could be used as basic material of adhesive layer.

+ Construction of refrigeration rooms: with ablity to resist wet conditions, high impact loads, foam XPS board has been used in refrigeration room construction. It can be used in all parts of refrigeration rooms including floor, interior and exterior walls and roofs or ceilings, etc. Furthermore, XPS used in houses are resistant to moisture and mold to ensure sanitary requirements.

- EPS foam

+ Used in building and construction for sound and thermal insulation.

+ Used in production of 3D panels in construction, villa or buildings replacing traditional materials because EPS is durable, lightweight and good insulation.

+ Used in ships, vehicles equipped with heat insulation equipment, refrigeration zoom.

+ Used as thermal insulation materials in floor of refrigeration zoom, freezing tunnels, ice water tanks, insulated pipes.

+ Used in electronic packaging, glass, anti-shock packaging materials.

There are many companies producing foam XPS, EPS panels in Vietnam such as Thang Long International Solution JSC; Dai Viet Refrigeration Electrical Engineering Corporation; Gia Nguyen Thermal Insulation Joint Stock Company; Okabe Joint Stock Company; Phat Loc Company; etc.

According to the information gathered from some companies which directly manufature XPS, EPS panels/sheets:

There are around 110 companies which produce XPS and EPS panels/sheets in Vietnam. The average production capacities of the companies is around 100 – 200tons/year. But all XPS and EPS materials have been imported from Taiwan. The imported XPS and EPS materials have been used for manufaturing XPS and EPS panels/sheets.

80% of the imported EPS and XPS materials is free from flame-retardant. The remaining imported EPS and XPS materials contain flame-retardant (HBCDs), which have an extra cost of 70 – 80 USD/ton. HBCDs level in the EPS and XPS materials have not been provided. EPS and XPS containing HBCDs have been used to buid prefabricated houses aiming to thermal insulation and waterproofing.

According to the requirement of Stockholm Convention, the companies will not import EPS and XPS materials containing HBCDs from 2018. However, according to quotation of producers in Taiwan, the EPS and XPS materials which use flame-retardant alternative to HBCDs have an extra cost of 20 USD/ton.

A second important application of HBCD is in polymer dispersion on cotton or cotton mixed with synthetic blends, in the back-coating of textiles. According to gathered information from the NIP update Project, volume of product group code 5903 (includes textile fabrics impregnated, coated, covered or laminated with plastics) is presented in following table.

Table 2. Estimate products group code 5903 [13]

Year	Weight (tons/year)
2013	305
2012	262
2011	201
2010	167
2009	133
2008	153
2007	145
2006	115
2005	115
2004	104
2003	94
2002	83
2001	78
2000	92
1999	62
1998	30

However, there is no information on identification of HBCDs or screening bromine presence in the product. In the coming time, it is nesscessary to identify HBCD in the products, which is basic for development of management measures.

- A further application of HBCD is in high impact polystyrene which is used in electrical and electronic equipment. Up to now, high impact polystyrene volume used in electrical and electronic equipment has not been inventoried. However, the NIP update project estimated amount of polymer in electrical and electronic devices as following:

Table 3. The amount of polymers in electrical and electronic devices in Vietnam from 2007 to 2014[14]

Year	Weight of the polymer; thousand tons
2007	337
2008	374
2009	425

[13] The NIP update Project. 2015

[14] The NIP update Project. 2015

2010	444
2011	476
2012	474
2013	511
2014	879

The above data shows that types of applications potential containing HBCD are popular used in Vietnam, and amount of these applications is significant. However, in order to identify what kind of products containing HBCD and amount of HBCD used in the products and in environmental components in Vietnam, Vietnam Government should carry out inventory of HBCD to orient safe management of HBCD in the future.

2.2. Situation of discharge of materials, products containing HBCD in Vietnam

Releases to the environment

HBCD is released into the environment during the manufacturing process, in the manufacture of products, during their use and after they have been discarded as waste.

The commercial mixture of HBCD may be used in the industry in manufacture of EPS, XPS, HIPS and textile coating. After its service, products containing HBCD will likely go to the landfill, or remain as waste in the environment or be incinerated.

- *Releases from industrial point sources*

There are direct emissions to air, direct discharges to waste water and to surface water from the industrial point sources.

HBCD is used solely as an additive in physical admixture with the host polymer, and can thus migrate within the solid matrix and volatilize from the surface of articles during their service life. There will also be particulate releases and leaching of HBCD during the service life of flame retarded end-products. Several studies have shown the occurrence of HBCD in indoor air and house dust, experiments revealing emissions of HBCD from various products and elevated levels in blood serum and breast milk likely related to exposure of products in use [15].

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[15] Stockholm Convention, HEXABROMOCYCLODODECANE - RISK PROFILE, 2010

- *Releases from waste*

Insulation boards form the majority of HBCD containing waste. It is understood that most of this material goes to landfill or incineration. The use of HBCD in insulation boards and in buildings and constructions is increasing. There will be releases of HBCD in dust when buildings insulated with flame retarded insulation boards are demolished. It is likely that those releases will be more significant in the future; as increasing numbers of buildings containing HBCD will be subject to refurbishment and demolition in the future.

Electrical and electronic appliances containing HIPS treated with HBCD are sometimes recycled, material that cannot be recycled will be disposed to landfill or incinerated. Other HBCD containing articles will be disposed into municipal waste, and the eventual fate of this material will also be landfill or incineration.

At present, assessment of disposal of materials, products containing HBCD has not been carried out in Vietnam. The data on amount of wastes containing HBCD, the amount of HBCD discharged into the environment has not been collected. However, according to the results of some studies mentioned in Section 2.3 of this report, HBCD has been found in analyzed samples that were collected in e-waste recycling villages in Vietnam. HBCD found in the samples shows that products and articles containing HBCD are disposed to landfills.

2.3. Some studies related to HBCD conducted in Vietnam

A number of studies analyzing HBCD levels have been conducted in some areas of Vietnam. However, scope of the studies and number of samples collected for HBCD analysis are very limited. Information on HBCD levels is not sufficient to assess HBCD levels in articles, wastes and in environment. However, these data provide initial information to help orientation for researches on HBCD in Vietnam.

2.3.1. Emerging halogenated flame retardants (HFRs) and HBCD accumulate in human foodstuffs in a Vietnamese e-waste handling area [17]

The study has been published in Environmental Science Processes & Impacts, 2016 conducted by Nguyen Minh Tue, Pham Hung Viet, Fang Tao, Hidenori Matsukami, Go Suzuki, Hidetaka Takigamib and Stuart Harrada.

This study reports concentrations of selected emerging halogenated flame

[17] F. Tao, H. Matsukami, G. Suzuki, N. M. Tue, P. H. Viet, H. Takigami and S. J. Harrad, Emerging halogenated flame retardants (HFRs) and hexabromocyclododecanes (HBCDs) accumulate in human foodstuffs in a Vietnamese e-waste handling area, Environ. Sci.: Processes Impacts, 2016, DOI: 10.1039/C5EM00593K

retardants (HFRs) and HBCD in foodstuffs sourced from an e-waste processing area in Vietnam. The estimated dietary intakes of emerging HFRs in this study were 170 and 420 ng/kg bw/day, for adults and children respectively; while daily ingestions of HBCD were estimated by 480 and 1,500 ng/kg bw/day for adults and children, respectively. Exposure at the site monitored in this study exceeds substantially estimates of dietary exposure to HBCD in e-waste processing sites and non e-waste processing areas elsewhere.

HBCD has also been frequently detected in environment and human milk sampled in the vicinity of rudimentary e-waste processing sites. Samples were collected in January 2014 from an e-waste processing area in Bui Dau (Cam Xa, Hung Yen province) in Vietnam.

The sampling area is a rural village of approximately 200 households. The main supplies of livestock products and fish for the local people in Bui Dau are from neighboring communities, and the livestock and fish raised in farm yards in Bui Dau are intended mainly for consumption by the families themselves with any small surpluses sold commercially. E-waste processing activities such as dismantling of electrical wires and metals, shredding of plastics into pellets, manual recycling of TVs, printers, printed circuit boards and other computer components are mainly family-based, with e-waste handled in the backyards of domestic buildings, in which livestock are raised. Fresh chicken eggs (n=3 from each site) were collected from chicken farm owners at six sampling sites. In addition, five chickens (one from each site) were also purchased from chicken owners at five locations, from which samples of chicken muscle (n=5), chicken liver (n=5), and chicken skin (n=5) were derived. Soil samples (one from each site) were collected at the same time from the backyards where the chickens were raised. Each soil sample analyzed consisted of five sub-samples from the same backyard homogenised before analysis.

In addition to chicken, egg, and soil samples; 1 five tilapia (*Oreochromis mossambicus*) samples were collected from the river, with a further five fish samples (3 rohu (*Labeo rohita*) and 2 tilapia) collected from the fish pond located in Bui Dau. Moreover, two samples of pork muscle were purchased from a market stall in Bui Dau village.

Concentrations of HBCD in food samples in this study are shown in Table 4. HBCD were detected in all chicken tissues, river fish, pork, and soil samples.

Table 4. Concentrations of HBCD in the samples

		Chicken muscle (n = 5)	Chicken liver (n = 5)	Chicken skin (n = 5)	Chicken egg (n = 15)	Soil (n=6)	River fish (n = 5)	Pork (n = 2)	Sediment (n = 8)
α-**HBCD**	average	34	1,700	600	2,800	6.7	2.5	0.9	-
	median	20	1,000	640	2,500	5.0	2.3	-	-
	range	1.2-55	180-2,500	20-850	330-3,500	1.0-8.9	0.1-3.3	-	-
β-**HBCD**	average	0.15	28	0.06	79	4.8	0.41	<0.002	-
	median	0.25	20	0.1	70	3.8	0.51	-	-
	range	0.1-2.0	2.5-35	0.02	0.15	15-80	0.5-8.0	0.04-0.65	-
γ-**HBCD**	average	5.3	1,500	330	700	110	0.5	0.2	-
	median	8.9	890	450	910	100	0.6	-	-
	range	0.1-15	160-3,000	3.8-580	200-2,300	56-710	0.05-0.12	-	-
Σ**HBCD**	average	39	3,200	930	3,600	120	3.4	1 .1	-
	median	29	1,900	1,000	3,500	110	3.4	-	-
	range	2.0-80	330-5,500	25-1,400	540-5,800	0.03-580	0.2-4.1	-	-

HBCD were not detected in river fish samples. This study found that HBCD concentrations in e-waste-impacted samples exceed those in corresponding controls. Average concentrations of ΣHBCD in chicken liver (3,200 ng/g lw) and egg (3,600 ng/g lw) samples in the study exceeded substantially those found in chicken liver and eggs from an e-waste processing area in Taizhou City, China.

As shown in Table 4, HBCD concentrations in animal-related food sampled from the e-waste processing site in Vietnam varied substantially 1 between species and different chicken tissues. The highest concentrations were found in chicken eggs, followed by chicken liver, chicken skin and chicken muscle; with concentrations in fish and pork samples much lower than those from chickens. Such interspecies differences indicate that the uptake and metabolism of HBCD is organism-dependent.

The mean ΣHBCD concentration in soil in this study was 120 ng/g dw, varying from 0.030 to 580 ng/g dw. According to the study result, HBCD to be the dominant isomer in soil samples in this study, similar to profiles observed in commercial technical products and related abiotic environmental matrices such as sediment, soil and sewage sludge. However in all food samples (whether sourced from e-waste impacted or control locations), α-HBCD predominated, in line with previous data for biota. Furthermore, α -HBCD was relatively more abundant in chicken egg, muscle, and skin than in liver, indicating tissue-specific variation in the relative abundance of different diastereomers. Whereby γ-HBCD is more prevalent in liver samples than the other tissues studied.

Daily dietary exposure to HBCD of individuals living in one e-waste impacted area in this study was estimated at 480 and 1,500 ng/kg bw/day for adults and children, respectively. This exceeds estimated dietary exposure to HBCD in e-waste impacted locations in China (10.4 and 36.1 ng/kg bw/day for adults and children), and is substantially in excess of estimated fish-related dietary exposure in the Netherlands and Sweden (0.12 and 0.14 ng/kg bw/day, respectively) as well as estimated dietary exposure of non-e-waste impacted populations in Spain, Belgium and China (2.58, 0.99, 0.432, 39.28 ng/kg bw/day, respectively.

High levels of HBCD were found in chicken, fish, and pork samples from an e-waste processing site (Bui Dau) in Vietnam. The main contributors to dietary exposure of both adults and children were chicken liver and chicken eggs. Estimated daily dietary intakes of HBCD were higher than those reported from other countries. This study provides evidence that HBCD are already entering the waste stream leading to environmental contamination when such waste is treated in an unregulated fashion. The author hypothesizes that over time, environmental contamination with HBCD will rise as increasing numbers of products containing these chemicals reach the end of their life.

2.3.2. Accumulation of polychlorinated biphenyls and brominated flame retardants in breast milk from women living in Vietnamese e-waste recycling sites.

The study was carried out by Nguyen Minh Tue, Tu Binh Minh, Pham Hung Viet, Agus Sudaryanto, Tomohiko Isobe, Shin Takahashi, Shinsuke Tanabe in 2009[18].

This study investigated the contamination status of PCBs, PBDEs and HBCD in human and possible exposure pathways in three Vietnamese e-waste recycling sites: Trang Minh (suburban of Hai Phong City), Dong Mai and Bui Dau (Hung Yen province), and one reference site (Hanoi City) by analyzing human breast milk samples and examining the relationships between contaminant levels and lifestyle factors. In each of the three recycling sites, the number of nursing mothers was limited to around 20 or less. Four breast milk samples from Dong Mai, eleven from Trang Minh and nine from Bui Dau were collected from the mothers who agreed to donate. As reference, another nine samples were collected from the capital Hanoi, a typical urban area. PCBs, PBDEs and HBCD were detected in all the samples analyzed.

According to the study results, the median ΣHBCD concentration in breast milk samples collected from Hanoi was 0.33 ng/g lipid wt; from Dong Mai was 0.42 ng/g lipid wt; from Trang Minh was 0.38 ng/g lipid wt and from Bui Dau non – recyclers was 0.36 ng/g lipid wt and from Bui Dau recyclers was 2 ng/g lipid wt. HBCD levels were not statistically different among residents of Hanoi, Dong Mai and Trang Minh (both recyclers and non-recyclers) and Bui Dau (non-recyclers). Recyclers from Bui Dau had significantly higher levels than the other groups with a 6-fold difference compared with the reference group.

α-HBCD was the dominant isomer in all the samples, accounting for more than 90% of the total HBCD levels. γ-HBCD was detected in eight samples with a proportion of less than 10% and β-HBCD was detected in only one sample.

[18] Nguyen Minh Tue, Agus Sudaryanto, Tu Binh Minh, Tomohiko Isobe, Shin Takahashi, Pham Hung Viet, Shinsuke Tanabe. Accumulation of polychlorinated biphenyls and brominatedflame retardants in breast milk from women living in Vietnamese e-waste recycling sites. Science of the Total Environment 408 (2010) 2155–2162.

Thus, according to the study, HBCD was found in breast milk samples. HBCD in the samples collected from recyclers were significantly higher than other groups.

2.3.3. Contamination of indoor dust and air by polychlorinated biphenyls and brominated flame retardants and relevance of non-dietary exposure in Vietnamese informal e-waste recycling sites

This study [19] investigated the occurrence of PCBs and several additive brominated flame retardants (BFRs) in indoor dust and air from two Vietnamese informal e-waste recycling sites (EWRSs) and an urban site. For air samples, only HBCD were analyzed and they were detected only in the urban indoor air and in air from the backyard e-waste recycling, at less than 10 pg m^{-3}. Average HBCD concentration is lower than that of other countries. This indicates that HBCD have been used with small volume in electronics and household products in Vietnam. The median HBCD levels were lower than the values reported for other countries, indicating low contents of HBCD in electronics and in Vietnamese household products.

Concentrations (ng/g) of HBCD in settled house dust samples from urban and suburban Hanoi and two e-waste recycling sites (Trang Minh and Bui Dau) is presented in Table 5.

Table 5. Concentrations (ng/g) of HBCD in settled house dust samples from urban and suburban Hanoi and two e-waste recycling sites

(Unit: ng/g)

	Suburban Hanoi (n = 7)		Urban Hanoi (n = 6)		Trang Minh (n = 10)		Bui Dau (n = 10)	
	Range	Median	Range	Median	Range	Median	Range	Median
α – HBCD	0.37 – 15	4.5	0.84 - 11	4.6	2.3 - 100	10	2.7 - 340	48
β – HBCD	ND – 4.0	0.48	ND – 2.1	0.78	0.61 – 8.0	2.5	1.0 - 34	4.7
γ – HBCD	0.57 - 47	3.3	0.46 - 21	4.0	4.6 - 44	8.6	1.7 - 110	8.4
Tổng HBCD	0.99 - 61	7.4	1.3 - 32	8.7	7.5 - 130	29	5.4 - 400	120

All three HBCD isomers (α, β and γ) were detected in house dust samples, with

[19] Nguyen Minh Tue, Shin Takahashi, Go Suzuki, Tomohiko Isobe, Pham Hung Viet, Yuso Kobara, Nobuyasu Seike, Gan Zhang, Agus Sudaryanto, Shinsuke Tanabe. Contamination of indoor dust and air by polychlorinated biphenyls and brominated flame retardants and relevance of non-dietary exposure in Vietnamese informal e-waste recycling sites. Environment International 51 (2013) 160–167

α being the most abundant in most cases, followed by γ and β (Table 5). This isomeric profile, also observed in air samples was different from those of the technical formulations, where the isomer γ accounts for 70% or more of total HBCD. The enrichment of α-HBCD in indoor environments may be due to γ-to-α isomerisation, occurring either at high temperatures during the processing of HBCD-containing polymers[20] or upon light exposure[21].

In the present study, house dust and air samples from Bui Dau showed a clear predominance of the α isomer, respectively 6 and 10 times more abundant than the γ isomer, based on median/average levels.

2.3.4. Contamination by brominated flame retardants in soil samples from open dumping sites of Asian developing countries.

The study is carried out by Akifumi Eguchi, Tomohiko Isobe, Annamalai Subraminian, Agus Sundaryanto, Karri Ramu, Tu Binh Minh, Paromita Chakraborty, Nguyen Hung Minh, Touch Seang Tana, Pham Hung Viet, Shin Takahashi and Shinsuke Tanabe in 2009.

According to the study[22], brominated flame retardants have been widely used in homes, workplaces and subsequently, they have become widely dispersed in the environment. The garbage containing them is dumped in refuse dumping sites, and causes pollution. But data on their environmental concentrations is scarce. The purpose of this study is to indicate the pollution status in Asian developing countries' dumping sites. The soil samples collected from those areas were analyzed for the concentrations of PBDE and HBCD. Concentrations of HBCD were N.D÷2.4 ng/g dry wt. The study found that PBDE contamination has spread in various parts of Asia but HBCD has not spread so much at present. Further studies are needed for continuous monitoring of the problems such as in flow of waste from developed countries.

HBCD was detected in 29 samples analyzed in this study. The average total HBCD concentrations are presented in Figs. 2. Comparing the average values of different countries showed the highest values in India, followed by Vietnam,

[20] Köppen R, Becker R, Jung C, Nehls I. On the thermally induced isomerisation of hexabromocyclododecane stereoisomers. Chemosphere 2008; 71:656–62

[21] Harrad S, Abdallah MA, Covaci A. Causes of variability in concentrations and diastereomer patterns of hexabromocyclododecanes in indoor dust. Environ Int 2009a; 35:573–9

[22] Contamination by Brominated Flame Retardants in Soil Samples from Open Dumping Sites of Asian Developing Countries.

Cambodia, Indonesia and Malaysia. As for the HBCD, higher values were found in the dumping site than the control site even though the differences were insignificant. HBCD concentration in this study is lower than the United States and Europe. Concentration of HBCD is low because the amount of the HBCD use in Asia is lower than in developed nations.

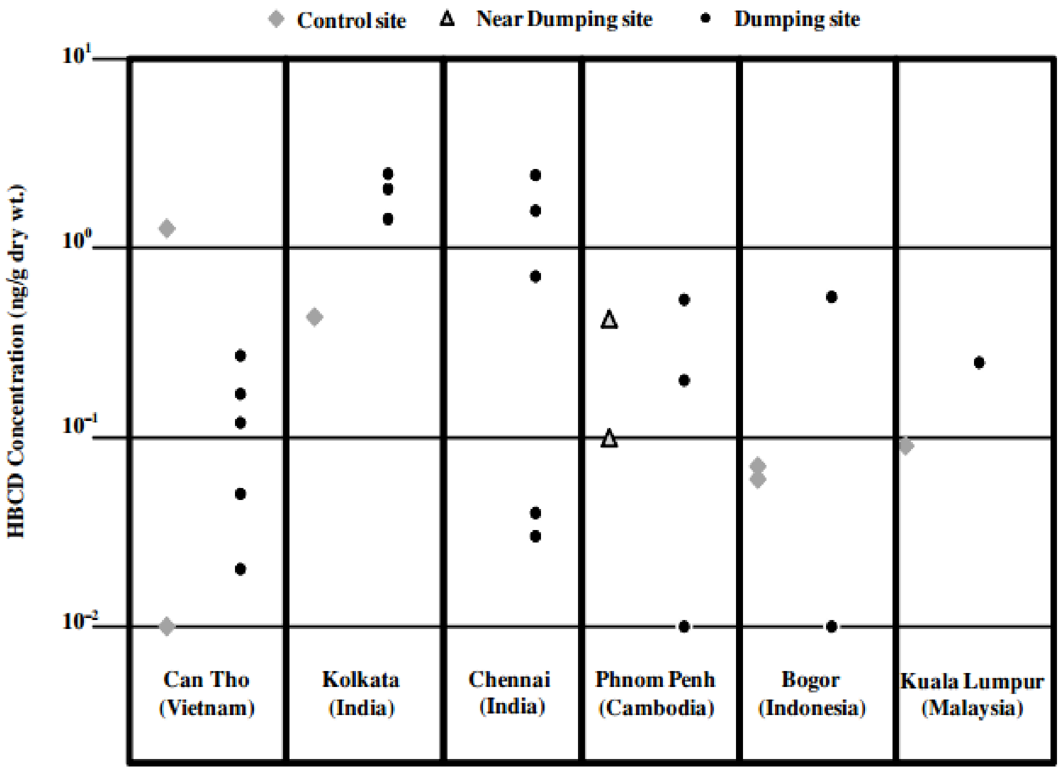

Figure 2. Concentration of HBCD in soil samples collected from Open Dumping Sites of Asian Developing Countries (ng/g dry wt)

Among the HBCD isomers detected, γ-HBCD was usually predominant. Technical HBCD product contains three diastereomers (α-, β- and γ-) with γ-HBCD contributing approximately 80% of technical formulation[23]. γ-HBCD has a strong binding affinity to soil. But in some places, α-HBCD was predominant. In the open dumping sites, heat generated by open burning and autogenous ignition may change the isomeric composition of technical HBCD mixture at temperatures above 160 ℃. Depending on the temperature of the treatment processes, the proportions of the isomers in the end product may also vary[24].

[23] Alaee, M. (2003): Recommendations for monitoring of polybrominated diphenyl ethers in the Canadian environment. *Environ. Monit. Assess*., 88(1–3). 327–341

[24] Tomy, G. T., W. Budakowski, T. Halldorson, D. M. Whittle, M. J. Keir, C. Marvin, G. MacInnis and M. Alaee (2004): Biomagnification of alpha- and gamma-hexabromocyclododecane isomers in a Lake Ontario food web. Environ. Sci. Technol., 38(8), 2298–2303.

Moreover, the water solubility of α-HBCD is higher than that of the γ-HBCD; the particle absorbance of the α-HBCD is weaker than that of the γ-HBCD and hence α-HBCD was found to move easily between different environmental matrices.

HBCD were from N.D to 2.4 ng/g dry wt. The levels of these compounds in the dumping site soils were higher than the levels in the respective control sites.

Summary:

So far, there have been few studies related to HBCD in Viet Nam, and some studies have found HBCD in air, food and breast milk samples in e-waste recycling sites. However, the number of samples analyzed in these studies is very limited. In the coming time, analysis and assessment of HBCD in environment, consumer goods and foodstuff and assessment of impact of HBCD on human health and the environment are essential to meet the requirements of the Stockholm Convention and protection of environment and human health against the risks caused by HBCD.

2.4. HBCD management situation in Vietnam

Currently, there are some legal documents provide direct or indirect regulation on management and use of HBCD, including:

a. Circular No. 07/2013/TT-BCT dated April 22, 2013 of the Ministry of Industry and Trade providing the registration of the use of hazardous chemicals for production of products and goods in the industrial sector.

According to Article 3. List of hazardous chemicals, Hexabromocyclododecane and all major diastereoisomers identified: Alpha-hexabromocyclododecane, Beta-hexabromocyclododecane, Gamma-hexabromocyclododecane, (1,2,5,6,9,10-Hexabromocyclododecane) have been listed the list.

Under the circular, organizations, individuals using hazardous chemicals must register for use by written form to the provincial Department of Industry and Trade within 15 (fifteen) working days before beginning the use.

Organizations and individuals must re-register for use of hazardous chemicals with the provincial Department of Industry and Trade within 15 (fifteen) working days after changing the owner or location or purpose of use. The registration form is prescribed in Annex 2 of this Circular.

Organizations and individuals using hazardous chemicals (including *Hexabromocyclododecane and all major diastereoisomers identified: Alpha-*

hexabromocyclododecane, Beta-hexabromocyclododecane, Gamma-hexabromocyclododecane, (1,2,5,6,9,10-Hexabromocyclododecane) must periodically report the use situation of hazardous chemicals based on content registered with the provincial Department of Industry and Trade before June 10 for the 6 (six) - month report; and before December 10 for the annual report.

b. Circular No. 36/2015/TT-BTNMT dated June 30th, 2015 of the Ministry of Natural Resources and Environment on management of hazardous wastes

HBCD containing wastes have not been directly managed under this Circular, and have not been listed in the list of hazardous wastes in Circular. However, insulation materials containing or contaminated with dangerous substances have been listed in the list of hazardous wastes. HBCD has been widely used in thermal insulation materials. Therefore, wastes formed from insulation materials could be containing HBCD. Organizations and individuals using, producing and discharging insulation materials should comply with Circular No. 36/2015/TT-BTNMT and Decree No. 38/2015/ND-CP dated April 24th, 2015 of the Government on the management of waste and scrap.

c. Decision No. 16/2015/QD-TTg dated May 22, 2015 provides regulations on recall and treatment of discarded products

Under the Decision, 'discarded product' refers to wastes derived from products which have been expired or discarded after being used. The product is listed in the Decision's annex.

Recall of discarded products refers to the act of receiving and collecting discarded products for management and treatment in accordance with legal regulations.

Under Article 3, electrical and electronic equipment has been listed in the list of discarded products. HBCD has been used in electrical and electronic equipment with levels ranging from 1 to 7 %[25] . The manufacturers have responsibility for recalling discarded products which were sold out to market in Vietnam. Consumers have responsibility for transferring discarded products in accordance with legal regulations.

d) Decree No. 113/2017/NĐ-CP dated October 09th, 2017 of the Government specifying and providing guidelines for implementation of certain articles of the Law on chemicals

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[25] Stockholm Convention, HEXABROMOCYCLODODECANE - RISK PROFILE, 2010

Under the provisions of this Decree, HBCD has been added in the list of chemicals subject to conditional production or trading and in the list of chemicals subject to declaration.

e) Decision No. 1598/QD-TTg dated October 17th 2017 of the Prime Minister promulgating the National implementation plan for the Stockholm Convention on Persistent Organic Pollutants up to 2025, with a vision to 2030

According to Clause 5, Article 1 of the Decision, some tasks related to HBCD has been mentioned in National implementation plan such as evaluating and identifying materials and products containing HBCD; controlling export and import of materials and equipment containing HBCD; monitoring HBCD in the environment, materials, products, waste and contaminated sites for risks assessment and implementation of environmental health management measures; evaluating, considering registration of exemption.

In addition, the Decision also provides other tasks to address POPs including HBCD, including control, treatment, rehabilitation and restoration of POPs contaminated sites; awareness raising, training and educating on risks posed by POPs and hazardous chemicals; strengthen capacity in research, development, monitoring, risk management, and safety management of materials, products, wastes containing POPs and hazardous chemicals.

According to this decision, relevant ministries and agencies have to carry out many tasks for safety management of HBCD up to 2025 with a vision to 2030.

2.5. Information on alternatives to HBCD in Vietnam

According to the documents of Stockholm Convention, HBCD have been used in many types of articles, which are being used in Vietnam. However, data on production and use of HBCD have not been collected. Current regulations have not specifically regulated management of HBCD containing products and applications, and alternatives to HBCD.

However, the above mentioned Decision No. 1598/QD-TTg has regulated safe management and reduction of HBCD use.

Nowadays, China use ProFlame - B843 as flame retardant for alternatives to HBCD. ProFlame - B843 is a fire retardant additive. The advantage properties of B843 are low dosage, low impact on the physical properties of materials, thermal resistant and stability under the effect of UV light. They are used in EPS, XPS and other styrol resins. They are especially suitable to use in plastic products which is processes at high temperature. B-843 is a good alternative to

HBCD. The bromine content of B-834: ≥65%; volatile content ≤0.3%; the melting temperature is ≥280^{0}C. ProFlame - B843 is being packaged in 25kg/bag or 1,000kg/bag and being sold in Vietnam market.

In addition, Vietnam have imported decabromodiphenyl oxide (Saytex 102E) from China. Decabromodiphenyl oxide is highly effective flame retardant that is widely used in rubber, textiles, electronics, plastics ....

Thus, Vietnam has used other flame retardants alternatives to HBCD, which are imported from China.

According to the reference from the Stockholm Convention, there are many flame retardant alternatives to HBCD such as benzene, ethenyl-, polymer with 1,3 butadiene, brominated; Tetrabromobisphenol A bis; 1,2,5,6-tetrabromocyclo-acetane; tetrabromophthalimide; Decabromodiphenylethane; Triphenyl phosphate; Diphenyl cresyl phosphate; etc.

III. CONCLUSIONS AND RECOMMENDATIONS

Hexabromocyclododecane has been listed in Annex A of the Stockholm Convention according to Decision SC-6/13 of COP.

HBCD has been used as an additive flame retardant, providing fire protection during the service life of vehicles, buildings or articles, as well as protection while stored. The main uses of HBCD globally are in expanded and extruded polystyrene foam insulation, second important application is in polymer dispersion on cotton or cotton mixed with synthetic blends. A further application of HBCD is in high impact polystyrene which is used in electrical and electronic equipment and appliances. In addition, HBCD has been used as fire retardant additive for rubber adhesives, adhesives, and paints. HBCD was produced in the United States of America, Japan, Israel and the Netherlands. HBCD has been used in different regions of the world. Demand of HBCD has been highest in EU. The total global demand of HBCD in 2001 was 16,500 tonnes, in which demand of Europe accounted 9,500 tonnes.

Vietnam Government has not assessed and identified HBCD levels in applications. However, according to documents published by the Stockholm Convention and other Parties, applications potential containing HBCD has been used in Vietnam.

Up to now, there have some of studies on HBCD in the air, food and breast milk in e-waste recycling villages in Vietnam which have been implemented by national coordinated with international experts. Although the number of samples analyzed in these studies was limited, HBCD has been found in the analyzed samples. This indicates that HBCD is used in electrical and electronic devices and HBCD released from recycling activities of electrical and electronic waste into the environment, organisms and the human body.

HBCD management has been mentioned in the National Implementation Plan for the Stockholm Convention on POPs and some other relevant regulations.. However, Vietnam has not carried out HBCD inventory. Therefore, in the coming time, HBCD inventory and assessment of HBCD level in environmental media and contaminated sites should be conducted in the whole country to provide reliable data which could be basis for development of management solutions of product and waste containing HBCD according to requirement of Stockholm Convention and Vietnam's context.

REFERENCES

1. Alaee, M. (2003): Recommendations for monitoring of polybrominated diphenyl ethers in the Canadian environment. *Environ. Monit. Assess*., 88(1–3). 327–341.

2. Bromine Science and Environmental Forum (BSEF). About Hexabromocyclododecane (HBCD). 2006.

3. Fang Tao, Hidenori Matsukami, Go Suzuki, Nguyen Minh Tue, Pham Hung Viet, Hidetaka Takigami, Stuart Harrad. Emerging halogenated flame retardants accumulate in human foodstuffs in a Vietnamese e-waste handling area.

4. European Chemicals Agency (ECHA). Data on manufacture, import, export, uses and releases of HBCDD as well as information on potential alternatives to its use. 2008a,108 pp.

5. Köppen R, Becker R, Jung C, Nehls I. On the thermally induced isomerisation of hexabromocyclododecane stereoisomers. Chemosphere 2008; 71:656–62.

6. Harrad S, Abdallah MA, Covaci A. Causes of variability in concentrations and diastereomer patterns of hexabromocyclododecanes in indoor dust. Environ Int 2009a; 35:573–9.

7. Nguyen Minh Tue, Agus Sudaryanto, Tu Binh Minh, Tomohiko Isobe, Shin Takahashi, Pham Hung Viet, Shinsuke Tanabe. Accumulation of polychlorinated biphenyls and brominated flame retardants in breast milk from women living in Vietnamese e-waste recycling sites.

8. Nguyen Minh Tue, Agus Sudaryanto, Tu Binh Minh, Tomohiko Isobe Shin Takahashi, Pham Hung Viet, Shinsuke Tanabe. Accumulation of polychlorinated biphenyls and brominated flame retardants in breast milk from women living in Vietnamese e-waste recycling sites.

9. Nguyen Minh Tue, Shin Takahashi, Go Suzuki, Tomohiko Isobe, Pham Hung Viet, Yuso Kobara, Nobuyasu Seike, Gan Zhang, Agus Sudaryanto, Shinsuke Tanabe. Contamination of indoor dust and air by polychlorinated biphenyls and brominated flame retardants and relevance of non-dietary exposure in Vietnamese informal e-waste recycling sites.

10. Report of the Persistent Organic Pollutants Review Committee on the work of its sixth meeting, Addendum - Risk management evaluation on hexabromocyclododecane, 2010.

11. Http://chm.pops.int/

12. Managaki S, Miyake Y, Yokoyama Y, Hondo H, Masunaga S, Nakai S, Kobayashi T, Kameya T, Kimura A, Nakarai T, Oka Y, Otani H and Miyake A.

Emission load of hexabromocyclododecane in Japan based on the substance flow analysis. 2009.

13. National Implementation Plan for the Stockholm Convention on POPs (The NIP update project).

14. Organization for Economic Co-operation and Development (OECD). SIDS Initial Assessment Profile for Cas. No. 25637-99-4, 3194-55-6, Hexabromocyclododecane (HBCDD). SIAM 24, 19-20 April 2007.

15. US Environmental Protection Agency (US EPA). Initial Risk-Based Prioritization of High Production Volume Chemicals. Chemical/Category: Hexabromocyclododecane (HBCD). Risk-Based Prioritization Document 3/18/2008.

PART III：

HBCD in insulation products and wastes from construction and demolition in Mongolia

Contents

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ABBREVIATIONS

BCRC - Basel Convention Regional Center for Asia and the Pacific

CDW – Construction and Demolition Waste

EPS- Expanded Polystyrene

HBCD- Hexabromocyclododecane

JICA - Japan International Cooperation Agency

UB- Ulaanbaatar

UBC- Ulaanbaatar City

GDP-Gross Domestic Products

GNI- Gross National Income

GCD- General Customs Department

GoM –Government of Mongolia

HIPS –High impact Polystyrene

MACMP- Mongolian Association of the Construction Materials Producers

MCUD- Ministry of Construction and Urban Development

MDDS- Morin Davaa Disposal Site

MNS- Mongolian National Standards

MSWM-municipal solid waste management

NEDS - Narangiin Enger Disposal Site

NWCUS -Narangiin Waste Collection Unified Site

POP- Persistent Organic Pollutants

PUR- Polyurethane

PVC – Polyvinylchloride

SCRCAP- Stockholm Convention Regional Center for Capacity Building and the Transfer of Technology in Asia and the Pacific

SME- Small and Medium Enterprises

TDDS-Tsagaan Davaa Disposal Site

TUK- City service and maintenance company

UBWRP -Ulaanbaatar Waste Recycling Plant

XPS- Extruded Polystyrene

FOREWORD

A present draft report is developed based on the study conducted in Mongolia under the Project "Sound Management of HBCD in Insulation Materials and Wastes Generated from Construction and Demolition in Asia-Pacific Countries".

Related consultancy agreement to conduct a local study within the Project was made with BCRC China/SCRCAP (Basel Convention Regional Center for Asia and the Pacific/Stockholm Convention Regional Center for Capacity Building and the Transfer of Technology in Asia and the Pacific) on 30 June 2017[1].

In line with the content of the Terms of Reference given by BCRC China/SCRCAP[2], the consultant has made a literature survey on HBCD in insulation materials and construction and demolition waste, reviewed acting national legislations and normative acts, met with industry representatives, government agencies in charge of waste management, construction and urban development, customs department, and professional associations to identify stakeholders on production, imports, construction applications and construction and demolition waste producers and to quantify HBCD contained insulation volumes, analyze HBCD disposal management situation in the country for further development of recommendations.

A draft report was kindly reviewed by Dr. Cheng Yuan, BCRC and Mr. Timo Seppala, Finnish Environmental Institute and author is grateful for their invaluable inputs for making the shape of the current report.

Present study is being constructed solely based on review and analysis of existing study reports and publications available due to resource and time limits given by the client.

The following reports and publications have been utilized as basis to construct the current report:

1. Final Report "Strengthening the Capacity for Solid Waste Management in Ulaanbaatar Ctiy" Sep 2012, Japan International Cooperation Agency (JICA) Project Team for SWM in Ulaanbaatar City Kokusai Kogyo Co., Ltd. MG JR 12-003.- 64 pages;
2. Baseline Study Report. ERM Japan Co., Ltd. Nov 2015. Ulaanbaatar Solid Waste Modernization Project Feasibility Study. Prepared for European Bank of Reconstruction and Development and with support from Japan-EBRD Cooperation Fund- 77 pages;
3. Somayeh Lotfi and Tommaso Troiani, Technical University Delft. Baseline Study on Construction and Demolition Waste Management. 2016 "Improving Resource Efficiency and Cleaner Production in the Mongolian Construction Sector through Material Recovery Project". Client: Caritas Czech Republic in financial support of European Commission and Czech Republic Development Cooperation- 47 pages;
4. Somayeh Lotfi and Tommaso Troiani, Technical University Delft. Study of the Mongolian Context and CDW Recovery Applications. 2016. "Improving Resource Efficiency and Cleaner Production in the Mongolian Construction Sector through Material Recovery Project". Client: Caritas Czech Republic in financial support of European Commission and Czech Republic Development Cooperation- 72 pages;
5. Bolorchimeg Byamba and Mamoru Ishikawa. Municipal Solid Waste Management in Ulaanbaatar, Mongolia: Systems Analysis. Journal Sustainability 2017, 9,896; doi:10.3390/su9060896;

For further inquiry on this report, please contact Dr. Erdensaikhan, consultant through email: erdene@environ.mn

INTRODUCTION

Mongolia is a landlocked country situated in East Asia, bordered by China and Russia. The largest city of Mongolia Ulaanbaatar (UB), which is the capital city of the country, is situated in the north center of the country and lies at an elevation of about 1350 m a.s.l. in a valley on the Tuul River. It is the country's administrative, cultural, commercial and financial capital. In 2015, the gross national income (GNI) per capita was US $3830[3], which is classified as a lower-middle-income country.

In 1990, Mongolia transitioned to democracy and market economy, which brought a series of unprecedented changes, especially in the development of the capital city's structure. During that time, an intense rural to urban migration took place and UB's population growth resulted in a large-scale increase of informal settlements—"ger districts"—across the city. Ger is a traditional dwelling that is unique to nomads in the steppes of Central Asia. Currently a half of population of Mongolia along is settled in UB. As location of Mongolia in cold climatic zone requires more insulations in any of buildings to keep the warm during long cold seasons.

Since country's shift to market economy, construction sector started recovering in 1994 [4]. With development of construction technology advancement in the world as well as in neighboring China, import and application of EPS/XPS and polyurethane insulation materials are being introduced in the construction sector of Mongolia. Since that time EPS/XPS and other insulations that contain HBCD became inseparable part of any buildings constructed in Mongolia.

Current study report describes types and estimated volumes of HBCD contained insulations either produced locally or imported and estimated current and future construction wastes of HBCD contained insulations as well as current construction waste management related legal acts and pros and cons of CDW practice management and developed recommendations to improve the situation for better management of HBCD contained insulation waste that is being generated and/or expected to be generated within 50 or more years.

HISTORICAL AND CURRENT USE OF HBCD AS INSULATION MATERIAL IN CONSTRUCTION SECTOR

Before 1990s, there is no data exist that proves use of polystyrene in construction in Mongolia. Also, there is no proper source of info, when polystyrene first imported as construction material and from where.

With recovery of construction sector of Mongolia by private companies in mid and late 1990s, more insulation materials became available in the local markets. That include traditional wools, straws, polystyrene and basalt wool. Since 2000, EPS became the most affordable and available building insulation material in domestic markets of construction material [5]. The source of this material was import from People's Republic of China.

According to 2014 data, about 770 factories in Mongolia are active to produce building materials among which 571 factories are located in UB[6]. This number corresponds with about 60% of the producers in the whole country.

Figure 1 shows the number of building material producers in UB distinctly.

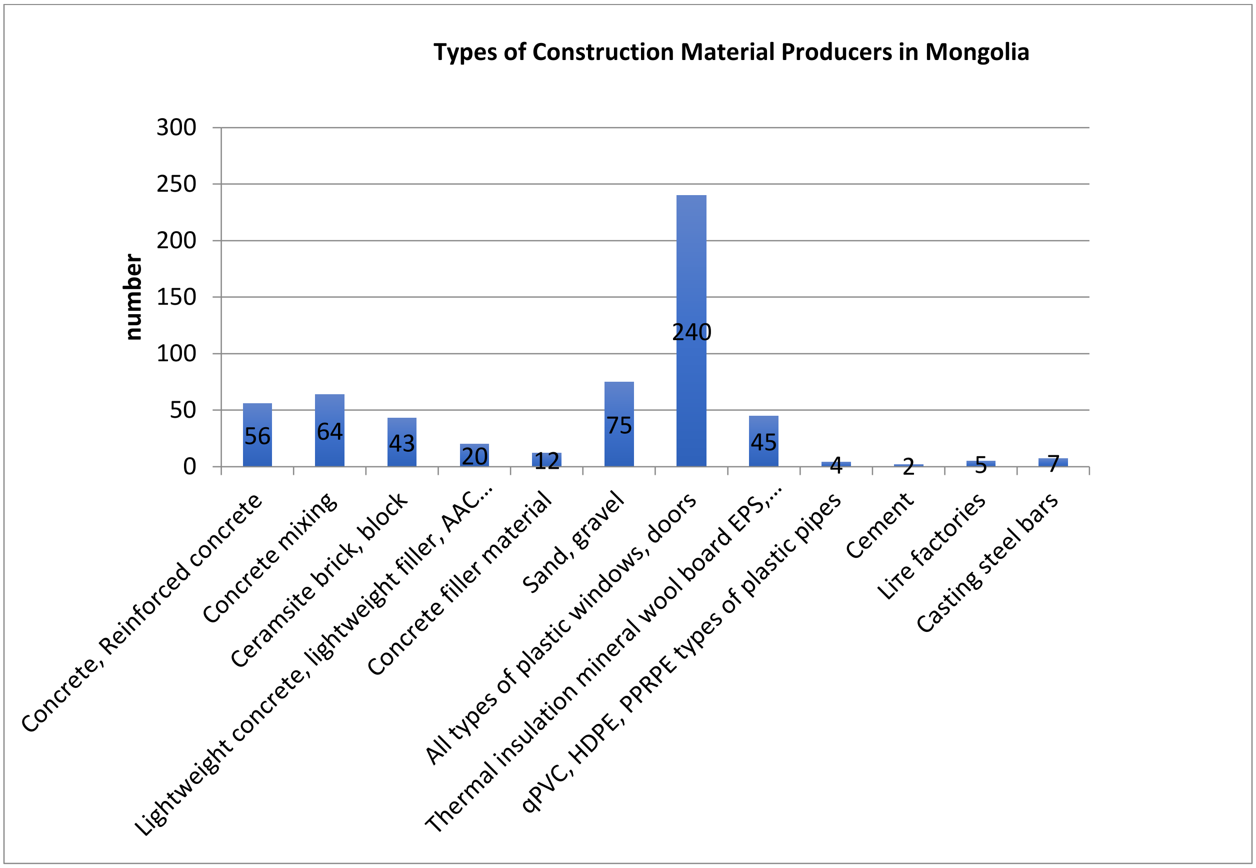


Figure 1. Types and numbers of building material producers in UB

Obtaining information regarding construction industry is a challenging activity in Mongolia, mostly because construction materials producers are often conservative to share data about their production. Among the producers, there is a general tendency to avoid sharing data to reduce the amount of taxes to be paid.

In –country Production of Insulation Materials

The climate in Mongolia is harsh continental with sharply defined seasons, high annual and diurnal temperature fluctuations and low rainfall. Because of the high altitude, Mongolia's climate is generally colder than other countries of the same latitude. With this natural settings, insulation of building and houses is one of very important construction components in Mongolia.
As of August 2017 data provided by the Mongolian Association of the Construction Materials Producers (MACMP), following types of building insulation materials have been produced currently in the country[7].

- Mineral wool
- Polyurethane
- EPS/XPS
- Sheep wool

Among these insulations, EPS are most dominant in the local markets in terms of availability and affordability of local buyers. There are currently 43 entities have been producing polystyrene insulation in Mongolia. Note that some of these entities produce insulation materials as well as panels, blocks with built –in insulation, therefore number of producers mentioned here and further in the text may overlapped. But the production type and specifically, production volume is not overlapped. There are only two XPS producers and four producers of polyurethane insulation.

In discussion with EPS producers found that there is no excessive waste of EPS produced during its production as most of companies use a crusher to make it smaller particle in order to re-utilize. Some producers like Gurvan Gal Group, has established a plant for producing a lightweight concrete blocks, in which EPS production waste or low quality EPS products are re-utilized through mixing with concrete[8].

With this reason, it assumed that there is no considerable EPS waste disposal in EPS production stage. However, considerable quantities of EPS are mixed with concrete and other substance and applied as ready-to-use construction materials with high insulation capacity.

In accordance with MACMP data (2018), there are 44 entities in Mongolia produce construction materials with increased insulation capacity [9]. That include concrete blocks, sandwiches, concrewalls with any or mix of the following materials sheep wool, perlite, expanded perlite, keramzit, polystyrene. Of 44 producers, 18 entities use polystyrene to produce construction materials with increased insulation capacity.

However, these lightweight concrete blocks, sandwiches and concrewalls, which use polystyrene as an ingredient for insulation have 2 times less polystyrene compared to insulation materials.

In order to produce a construction material, Ministry of Construction and Urban Development of Mongolia as a central government body in charge of regulating relations on construction and urban development within the territory of Mongolia, requires to obtain a license for construction material production and a certificate for quality of a product that meets the national standard requirements [7].

All above mentioned producers either insulation materials or panels, blocks, and sandwiches with built-in insulations have obtained the license from the Ministry of Construction and urban Development of Mongolia.

These producers are obliged to follow the following national standards to ensure quality of their products:

1. Mongolian national standard MNS EN 13163:2011 Thermal Insulation Products for Buildings. Factory Made Products of Expanded Polystyrene (EPS). Technical Requirements
2. Mongolian national standard MNS EN 13164:2011 Thermal Insulation Products for Buildings. Factory Made Products of Extruded Polystyrene (XPS). Technical Requirements
3. Mongolian national standard MNS 6318 – 2012 Concrewall Panel with Expanded Polystyrene. General Technical Requirements
4. Mongolian national standard MNS 5771 - -2007. Polystyrol Concrete. Technical Requirements

Except provisioning of the certificates to those private companies that meet the requirements, MCUD does not regulate or pay attention on the number of businesses and production volume, quantity and quality of EPS/XPS. As witnessed, consultant has experienced some difficulties in obtaining national level figures on production of EPS/XPS, as these figures are missing in the government led statistical reports and within MCUD. Attempts obtaining local production data based on the paid taxes to government through taxation office did not bring results.

As private producers, EPS/XPS production companies tend to avoid government taxes through not giving their production capacity and sales figures. A weak control over production and income by the government contributes in difficulty finding those statistical data. In order to overcome such a situation, the researcher has selectively discussed with producers from small, medium and large production companies and based on the findings on regularity of their work regime (whether operates through all season or during construction season in warm period; if there is work shift during a day) made estimation of volume produced per construction season (from April to October) and annually.

EPS production

There are 43 EPS production companies are functioning in Mongolia [8], of which 34 producers are located alone in Ulaanbaatar city and other 9 producers are spread across Mongolia.

Total accrued production capacity of these producers to date are 1,627,600 cubic meter per year (figure 2 annual EPS production capacity in Mongolia). In discussion with some producers we found that they do not fully utilize their installed capacity due to low construction market demands [8].

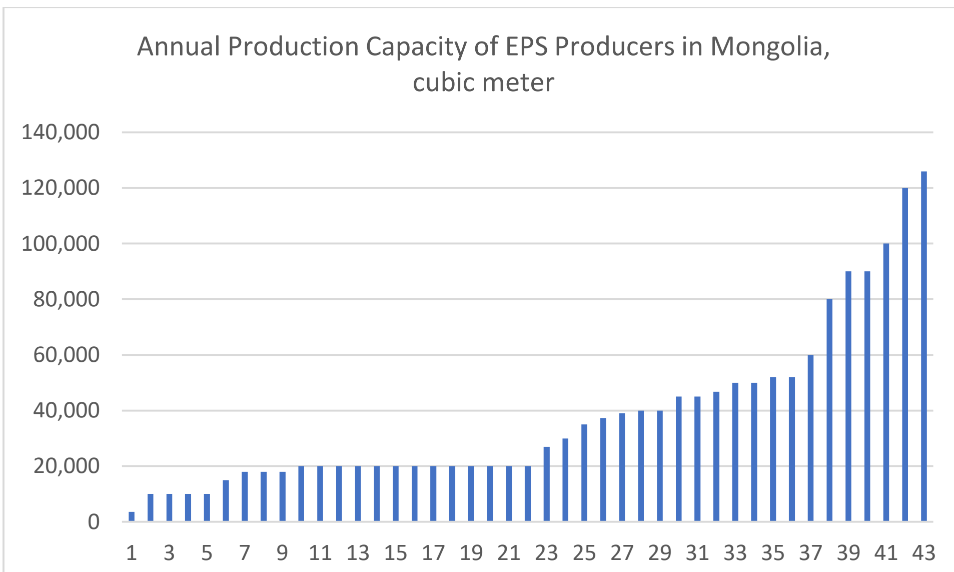


Figure 2. Annual EPS production capacity in Mongolia

It is obvious that the market demand is well correlated with economic development of the country. Since Mongolian shift to market economy in 1990s, its construction sector started show recovery signs at the beginning of 1995 and started thriving (Figure 3) when Mongolia economic development was reached its record level in 2011 with GDP growth rate of 17% [10]. The sharp economic development was largely due to increased commodity price of mineral resources in the world as well as intensive development of neighboring country China. In past 6 years from 2012-2017 the GDP growth rate fallen till -1.6 in the second half 2016 and raised in 2017 with a mean GDP growth rate of 5.1%.

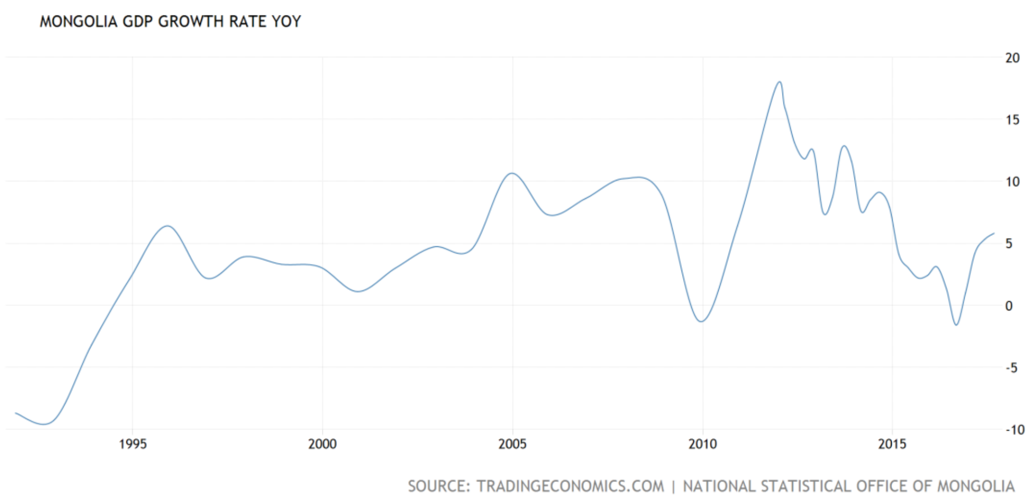
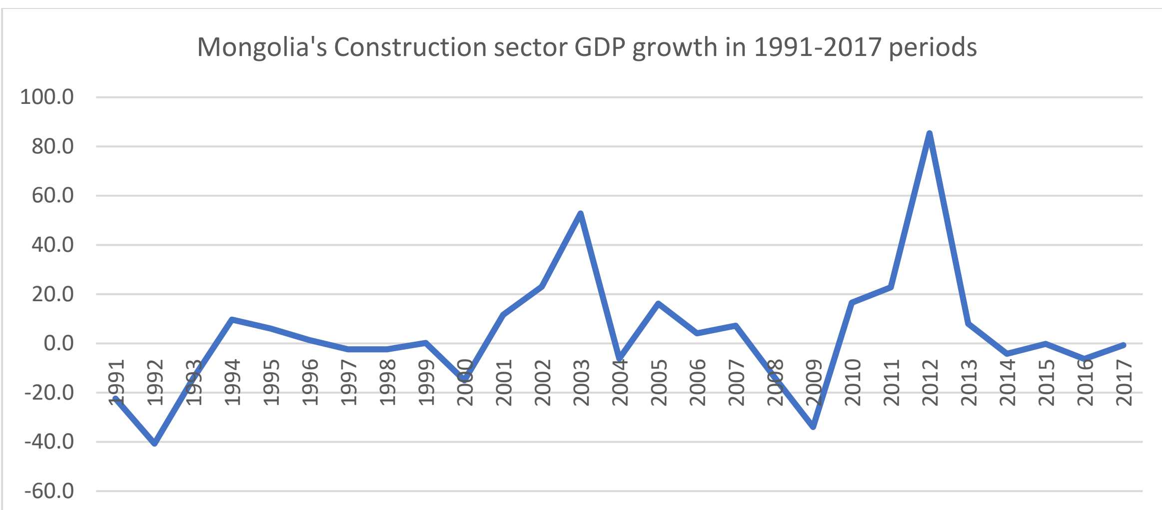


Figure 3. Gross Domestic Production Rate of Mongolia over 27 years.

Whereas, GDP growth rate in construction sector of Mongolia in period of 1991-2017 depicts well ups and downs of this important sector of Mongolia.



(Source: National Statistical office, 2018)

Figure 4. Mongolia's Construction sector GDP growth

As there is no reliable data exists on annual produced and sold EPS in the internal market of Mongolia, we made estimation based on the annual production capacity and economic situation within the country in last 5-6 years and GDP growth in construction sector in the study period.

In order to make an estimation of total produced EPS products in country, analysis was done based on the dates of the producers' establishments (Figure 5). According to this graphics, 22.7% of producers started EPS production as early as 2002-2008 period and majority (72.7%) of producers started their production within 2009-2014 period. Only 2 more companies established in last two years. Therefore, majority of EPS production volume falls within 2009- 2014 period.

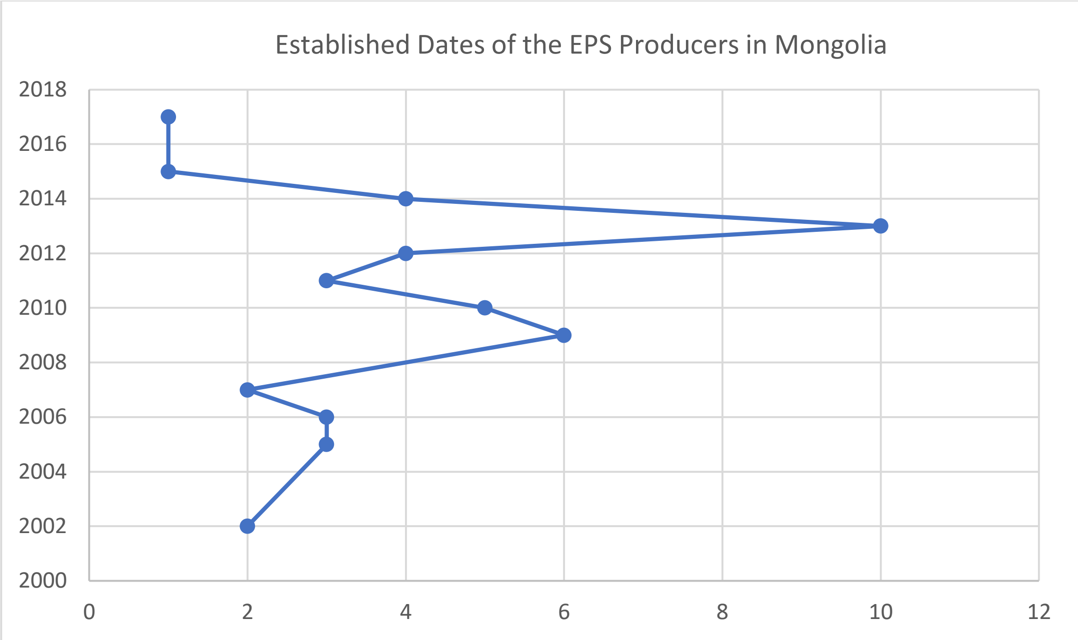


Figure 5. Producer's established dates

Construction GDP growth rates in period of 1991-2017, historical data of production capacity of insulation producers [9] were used to estimate overall production volume of most popular insulation EPS in Mongolia during the study period.

Table 1. Estimated Annual EPS production in Mongolia

Year*	Accumulated production capacity of EPS producers	construction GDP growth rate	Production capacity utilization** %	EPS production estimates
2002	75,000	23.0	0.230	17,250
2003	75,000	52.8	0.528	39,600
2004	75,000	-6.2	0.009	675
2005	135,400	16.1	0.161	21,799
2006	222,676	4.1	0.041	9,130
2007	260,676	7.2	0.072	18,769
2008	260,676	-13.8	0.005	1,303
2009	609,676	-34.0	0.001	610
2010	807,676	16.5	0.165	133,267
2011	889,676	22.7	0.227	201,956
2012	1,074,676	85.3	0.853	916,699
2013	1,587,676	8.0	0.080	127,014
2014	1,769,676	-4.3	0.010	17,697
2015	1,769,676	-0.2	0.030	53,090

2016	1,769,676	-6.3	0.008	14,157
2017	1,789,676	-0.8	0.020	35,794
Estimated total EPS produced during 2002-2017, in cubic meters				**1,608,810**

Remarks:

*- first EPS producers of Mongolia started EPS production in 2002

**- Production capacity utilization expressed in per cent- in order to find produced EPS volume annually, it assumed that sold insulation products in particular year is well linked to construction GDP growth rate of that year. Based on this assumption, construction GDP growth rate was applied as utilization rate of established capacity of a producer.

As table 1 data describes, 1,608,810 cubic meters of ESP were produced in Mongolia during 2002-2017 period. To note that finding production volume either annual or for entire study year was the most challenging task for consultant.

Flame retardant and non-flame retardant polystyrenes

There were no specific requirements in terms of application limits in civil construction for EPS/XPS insulations in construction related legislation of the country before 2011.

With approved standards “Mongolian national standard MNS EN 13163:2011 Thermal Insulation Products for Buildings. Factory Made Products of Expanded Polystyrene (EPS). Technical Requirements” and “Mongolian national standard MNS EN 13164:2011 Thermal Insulation Products for Buildings. Factory Made Products of Extruded Polystyrene (XPS). Technical Requirements”[12], producers were requested to comply with densities set in these standards and produce polystyrene with higher densities.

In terms of fire safety, Mongolian standard MNS 4999 – 2000 Flammable products and their classification and rating was enforced to limit flammable products to be used in the country. However, to note that compliance monitoring of legislative requirements are still a problem in Mongolia in construction sector and it is under question that fire safety requirements have been strictly implemented.

In 2015, Parliament of Mongolia has adopted renewed Law on Fire Safety [13], which made fire safety provision specifically on building insulations EPS/XPS.

Currently most of producers possess a polystyrene production technology with flame retardants in Mongolia and only three producers have a technology with non-flame retardant [8]. Production of FR free EPS is a quite limited and buyers are small home owners.

Additional interviews and surveys have been done to address the comments of Mr. Timo Seppala, Senior Adviser of the Finnish Environment Institute. Specific comments for Mongolia study were as follows:

- the lack of national legislation may mean HBCD has not been used at all

- This needs to be studied from the companies and importers, and if no information is found, run a screening study on insulation materials with an XRF.

In order to find more info researcher has met Mr. Bayan Erdene, officer at Disaster Research Institute of the National Emergency Management Agency, Ms. Batjilmaa, senior officer of Division of Construction Norms and Normative, and Ms. Erdenechimeg, senior officer of Division of Construction Materials Production, of the Construction Development Center, a government regulatory agency under the Ministry of Construction and Urban Development of Mongolia.

As it found through discussing with government officials, there is no specific regulation exists that either allows or prohibited use of flame –retardant or non-flame retardant polystyrene in the construction sector. This means there is no restriction for ordinary EPS without HBCD in the construction sector in the country.

In addition to this, researcher has met with four EPS producers (Jargalant-Uuduu LLC, Tsonjai LLC, UBS LLC, and Dulaan Huus LLC) to clarify if they produce EPS with FR or not and production and sales volume and local demands and practices for either products.

Findings are as follows:

- There is a difference in production technologies of both non-FR and FR contained EPS
- Production technology is a rather complicated with regard to non-FR, although it is cheaper on the market
- Non-FR EPS are applied as insulation materials for 1-2 story buildings and individual homeowners are the main buyers.
- All PES bead materials are imported from China and most of producers in Mongolia have acquired a technology that produces FR contained EPS. Due to language barrier in communicating with Chine partners, Mongolian small scale producers prefer to acquire technology, which is proved to be working reliably or acquire the same technology, which already bought and running by Mongolians. Because of limited knowledge of technology and communication barrier, most of producers in Mongolia use technology and bead materials that contain HBCD.
- As constructors of high rise buildings and apartments, especially those, who make a largest portion of EPS insulation users, prefer use of EPS with HBCD, to show to potential buyers as an additional sign of quality of their buildings for increasing sales and higher profits. Therefore, producers are avoid using non-FR EPS, which they see as an additional risk for them in case of large scale fire. FR contained EPS are largely bought by constructors, which build apartment buildings and high rise buildings as insulation materials in outer walls.
- Despite above facts, it is difficult to estimate volume of production and sales for no-FR polystyrene and as price is also main driven force for most of EPS buyers, non-FR polystyrene are widely used among poorer clusters of society.

Based on this info, it is estimated that 50 % of total polystyrene produced contains HBCD flame-retardant. Thus, out of total 1,608,810 cubic meter of EPS produced during 2002-2017 in country, 50% or 804,405 cubic meter was HBCD contained EPS.

At current, the most popular building insulation material in urban areas of Mongolia is EPS with varying density. Recent structural fires occurred in high rise apartment buildings that applied similar to EPS type insulation in the world show that it is dangerous for human life in terms of fire safety. Moreover, EPS with low density is mostly sold in the local market due to its cheap price and public safety related government organizations do not pay proper attention. One of the recommendations of this study should be focused on building fire safety issues in addition to strengthening of HBCD regulation as PoPs in construction and waste management.

XPS Production

On extruded polystyrene, two companies produced XPS during 2014-2015 period and their production has been stopped in 2016-2017 period by the government because of use of ozone depletion substances and to change their technology so that to green their production to reduce negative effects to climate [14]. During 2014-2015, these two companies estimated to produce 30,000 cubic meters of XPS. We assume that 50% of which or 15,000 cubic meter was HBCD contained XPS. According to producers, they have changed the technology by the end of 2017 and ready to produce XPS in 2018.

HIPS Production

There is no info within authority of Mongolia exist on HIPS production [7,8,9]. Basalt wool and sheep wools also have been produced by some companies. But the high market price of these insulations force majority of consumers in Mongolia in buying EPS for building insulations due to their low purchasing capacity.

If the market demand increases, existing plants will work at its established capacity and more EPS/XPS will be generated in the construction sector and moreover, more foam waste will be disposed consequently coming years.

Concrete-Polystyrene Production

As mentioned in the first section, 18 producers of concrete-polystyrene panels and blocks operate in Mongolia to date. All of the producers are a quite new. As government statistic shows they have obtained their license for production from the government in recent years. Oldest producer has obtained the license on July 2013. Then 5 producers obtained production license within first half of 2014. Another 5 producers obtained license in last half of 2014 and last 7 producers in first half of 2015. Their total established annual production capacity is 2,250,000 m^2 [9]. To note that the statistical data on these producers' capacity and produced volume of products were not full.

These producers obtain polystyrene from polystyrene producers and then mix it with concrete and iron armature to produce concrete –polystyrene insulation products. 50% of one square meter product contains polystyrene [8]. In discussion with concrete-polystyrene producers found that although they tend to use polystyrene with no flame retardant, its availability on the local market is a quite limited. Therefore, polystyrene with flame retardant is used mostly as filling ingredient in the concrete panel or blocks.

The following criteria were used to estimate the total volume of concrete-polystyrene products between 2014-2017 period in Mongolia:

- Government obtained data on annual capacity is applied
- Production duration was taken as 3.4 years (arithmetical average of production duration of total producers)

- Production/sales rate was estimated as 30% (low market demand due to slower economic development within country)
- 50% of total products contains polystyrene with HBCD

Considering the above criteria, it is estimated that 1,125,000 m^2 of concrete-polystyrene insulation with HBCD was produced and applied in construction sector in Mongolia in last 3 years.

Table 2. Summary of Findings in Insulation Production with HBCD in Mongolia

Production Types	Production Volume	Without fire-retardant	Products with HBCD
EPS	1,608,810 m3	50%	804,405 m3
XPS	30,000 m3	50%	15,000 m3
Concrete-Polystyrene	1,125,000 m2	50%	573,750 m2

In total, 819,405 cubic meters of HBCD contained EPS/XPS and 573,750 square meters of HBCD contained EPS/XPS panels have been produced in Mongolia during 2002-2017 period.

Insulation Imports

The construction industry has expanded rapidly in recent years in Mongolia and demand for all types of construction products (from concrete to metals) is expected to increase in the coming years. Currently more than 50% of building materials are imported (table 3). Therefore, imported products made from new raw materials are transported for long distances, resulting in high “carbon footprint” and significant contribution to climate change.

Although the government follows the policy of increasing the local production of building materials, it still faces problems. The main reason is that the local products are not able to compete with imported ones in terms of price and profitability. Tables 3 presents the amount of building materials which are locally produced or imported from other countries [15].

Table 3. List of materials used in construction and percentage of imported quantity

Material name	Percentage of locally produced	Percentage of imported
Concrete mixture, chemical additives for concrete	100	0
Ceramic brick, block	100	0
Lightweight concrete, lightweight filler, AAX blocks	100	0
Concrete filler material, construction sand, construction stone	100	0
All types of plastic windows, doors	100	0
Thermal insulation mineral wool, board, EPS, XPS, PUR type of polystyrene foam panels, composite structures magnesium and OSB panels, bars, and sandwiches plate	75	25

PVC, HFPE, PPR, PE types of plastic pipes underground montage hose, electrical wire threading pipes and wiring box	100	0
Cement, Lime, mineral powder	30	70
Casting, steel bars	30	70
Dry and wet mixtures for interior	30	70
Steel and cast iron pipe and its connection tools, heating ventilation accessories	0	100
Ceramic finishing, plumbing, ceramic products, artificial stones	0	100
All types of glasses	0	100
Different types of floor and doors	25	75
Steel bars and steel hiring of nails and screws	70	30

In order to estimate the volume of imported EPS/XPS/HIPS, the researcher approached the Statistical division of the General Customs Department (GCD) and has obtained [16] the following info:

- Import data mixed materials for last 23 years have been obtained.
- All materials are being imported from neighboring China
- Raw materials used for insulation in construction such as perlite and vermiculite are grouped together with EPS/XPS under the one single code to ease the registration within the import information system of the GCD. This situation hinders in properly estimating imported quantities of EPS/XPS in a given period.
- For making estimation of how much EPS/XPS materials imported to Mongolia, it assumed that 1/3 of mixed products under single code is from EPS/XPS;

Based on the above assumption, the total polystyrenes (a raw base material) imported in last 23 years was calculated (table 4)

Table 4. Imported Quantity of EPS/XPS in last 23 years, in tons

no.	year	Total imported mix products under the single GCD defined code	Quantity of EPS/XPS base material imports (1/3 of mix)
1	1995	0.17	0.06
2	1996	1.50	0.50
3	1997	12.64	4.21
4	1998	17.59	5.86
5	1999	72.38	24.13
6	2000	147.05	49.02
7	2001	113.15	37.72
8	2002	90.54	30.18
9	2003	0.18	0.06
10	2004	0.25	0.08
11	2005	0.39	0.13
12	2006	332.23	110.74
13	2007	649.09	216.36
14	2008	629.68	209.89

15	2009	346.54	115.51
16	2010	1,149.94	383.31
17	2011	3,526.06	1,175.35
18	2012	317.38	105.79
19	2013	44.97	14.99
20	2014	127.17	42.39
21	2015	186.28	62.09
22	2016	84.13	28.04
23	2017*	37.53	12.51
	total	**7,886.84**	**2,628.95**

Remarks: *- 2017 data is not complete and it includes import data of up to July

(Source: Statistical division, General Customs Department of Mongolia, Aug 2017)

Notes on credibility of customs data. As a developing country in transition from centralized to market economy, Mongolia faces multiple challenges in terms of renewing legal system, adjusting to market economic relations, supporting of private sector development, social equity and justice and fighting with corruption in public services and crimes. According to the national anticorruption report of Mongolia 2016 (http://www.business-anti-corruption.com/country-profiles/mongolia), there is a high risk of corruption within the customs administration; irregular payments are common when importing and exporting goods [17]. Ten percent of companies in the trade sector encounter corruption in the course of their work [18]. When getting an import license, 19 percent of businesses expect to exchange informal payments to officials. Mongolian citizens perceive customs officials to be corrupt [19]. Companies consider the lack of transparency and efficiency at the border administration a competitive disadvantage [20]. With these reasons, it assumes that available import data on EPS/XPS are not fully reflect the actual situation of product import and the figure of imported goods in fact might be at least 20-30 % higher than the official records.

In spite of this, table data shows that import of EPS/XPS started in 1995 and steadily increased until 2000 and after 2002, it falls to 1995 level. A sharp increase observed in 2006 and the peak reached 2011 by importing 1,175 ton of EPS/XPS products. It is interesting to note that these ups downs in imports are well correlated with economic situation,especially, in construction sector in Mongolia.

Until 1990 Mongolia's construction sector was at its highest development stage and after collapse of socialist system in 1990 the construction sector falls down until 1995. First sign of recovery was observed in 1996 and because of harsh winter situation that negatively influenced economy of the country during 2001-2004, the construction sector performance was again down. (Figure 7).

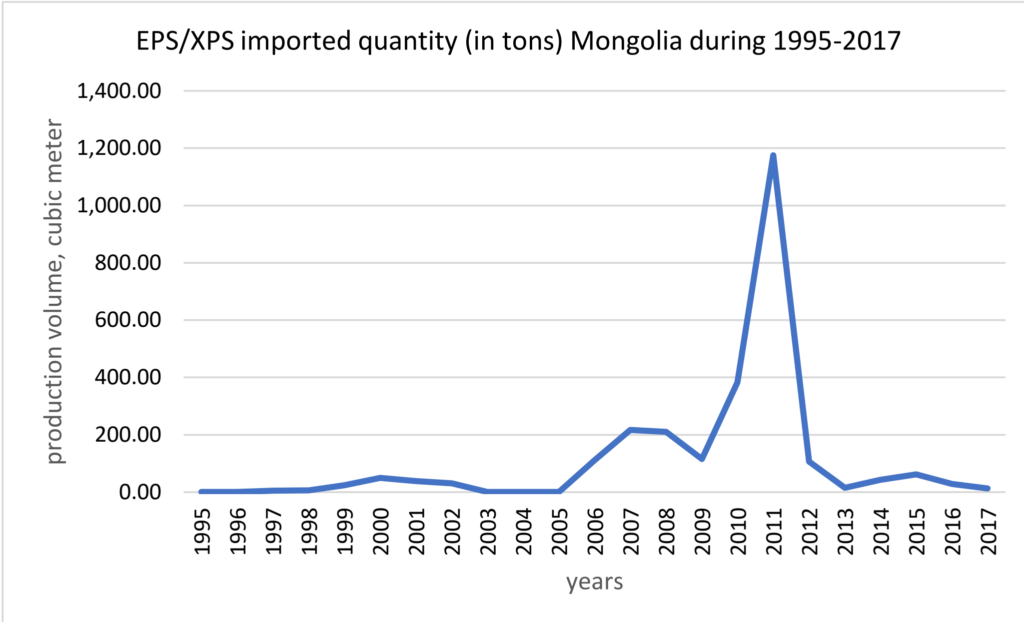


Figure **6**. EPS/XPS imported quantity (in tons) Mongolia during 1995-2007

With increased commodity price of mineral resources in the world market 2008-2009, mining boom started in Mongolia, which hauls country's economy forward and thus, import of construction materials is sharply increased, including EPS/XPS imports [11]. After 2012, due to commodity price fluctuation, Mongolia' economic rate is significantly reduced down to 2.4% in 2015 and more down 1.0% in 2016 [21].

There are some signs of economic recovery in the second quarter of 2017 according to the information of the National Statistical Office of Mongolia and GDP growth rate is estimated in 4.2% at this period [10]. As response, production and imports of EPS/XPS will be increased again in near future.

Considering all above data on imports of EPS/XPS and facts and assumptions on customs reduced registration of EPS/XPS import, it is estimated that 3,154.71 tons of EPS/XPS base materials were imported. There has been added 20% or 525.79 tons of total imported EPS/XPS as portion, which might have been imported but not registered at customs entry points. Another assumption taken on portion of EPS and XPS is that of imported EPS and XPS, portion of EPS is 80% and remaining 20% is XPS.

That way, of total 3,154.7 tons of imported HBCD contained EPS/XPS, EPS was 2,043.4 tons and XPS - 510,8 tons were imported during 1995-2017 period.

Again due to lack of credible info on whether EPS/XPS imported are with fire retardant or not, it assumed that 50% of total imported EPS/XPS are without fire retardant. That means, 1,021.7 tons are HBCD contained EPS and 255.4 tons are HBCD contained XPS.

Thus, Mongolia has imported in total 3,154.7 tons of EPS/XPS base materials during 1995-2017 period [16].

THE GENERATION TRENDS OF INSULATION WASTE CONTANING HBCD IN THE FUTURE 50 YEARS

As estimated in the previous section, current annual HBCD containing insulation production capacity in Mongolia is 575,400 m3 for EPS. In May 2013 HBCD was identified as a persistent organic pollutant (POP) under the Stockholm Convention and insulation production that contain HBCD will be completely banned by 2021. Based on the production capacity, the total volume of HBCD containing insulation production was estimated up to 2021 (table 6). While estimating total volumes, the following assumptions were considered:

- As indicated Economic Forecasts of Mongolia 2018-2020 Outlook data [22] GDP rate is expected to be 4.57% in 2018 and 5.9% in 2020. The second source, World bank Group forecasted higher GDP rate- 6.8% in this year [23].
- In addition to above of economic forecast sources, a simple one step forecast was developed using time-series data of Construction GDP of Mongolia in period of 1991-2017. MS excel function with confidence interval of 95% (figure 8) was used for forecast. According to this forecast result, GDP growth in construction expected to be positive: 6.6% in 2018, 5.5 in 2019 and 4.4 in 2020. Thus we assume that insulation producers will continue utilize 6.6-4.4% of their established capacity.
- Imports on HBCD containing insulation base materials will be continued up to 2021 at the same rate as an annual average volume of last 5 years, excluding 2017 with no complete data (refer to Table 5 of the previous section). The average annual import volume is 50.66 tons of EPS/XPS of which 50% is HBCD containing insulation base material.
- For other insulation such as XPS, PUR and concrete- polystyrene, current annual capacity is taken for estimation of total volume.
- HBCD contained EPS is assumed 50% of total EPS annual production
- No new producer established during the forecast period

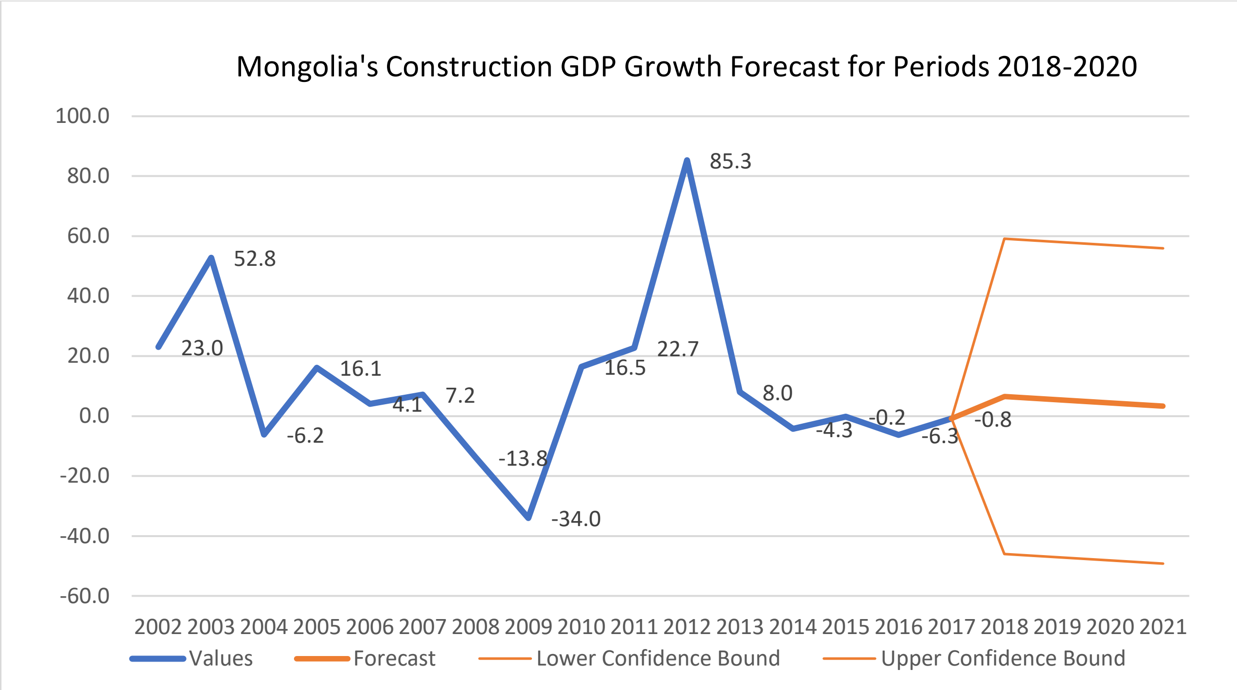


Figure 7. Mongolia's construction sector GDP growth forecast in period 2018-2020.

As Forecast resulted, GDP growth in construction is expected to be all positive in three consecutive years: 6.6% in 2018; 5.5% in 2019 and 4.4% in 2020. Forecast values, as well as upper and lower confidence values are reflected in the table 5.

Table 5. Forecast Values with Lower and Upper Confidence Bounds

Years		Forecast value, %	Lower confidence bound	Upper confidence bound
2018		6.5	-46.0	59.1
2019		5.5	-47.1	58.0
2020		4.4	-48.1	57.0
2021		3.4	-49.2	55.9

Based on above assumptions, the produced forecast values are reflected in the table 6, describing quantities of HBCD contained insulations to be accumulated in upcoming 3 years from now.

Table 6. Forecasted Production and Import of HBCD Contained Insulations in Mongolia until 2021 year

Types of insulation with HBCD	Annual production capacity	Production volume			Grand total
		2018	2019	2020	

EPS in country production	894,838 m3 (50% of total capacity for HBCD contained EPS)	58,164	46,741	39,373	144,278 m3
XPS in country production	7,500 m3 (50% of capacity to produce XPS with HBCD)	7,500	7,500	7,500	22,500 m3
Concrete-Polystyrene	1,125,000 m2 (50% is with HBCD)	73,125	61,875	49,500	184,500 m^2
Imported EPS	-	20.3	20.3	20.3	60.9 ton
Imported XPS	-	5.6	5.6	5.6	16.8 ton

Within 3 years from now, Mongolia will be expected to produce 144,278 cubic meters of EPS; 22,500 cubic meters of XPS; 184,500 sq. meters of concrete-polystyrene; and will import 77.7 tons of EPS/XPS insulation base materials that all contain HBCD.

Grand total of all produced and future production of HBCD contained insulations as well as imported HBCD amounts are reflected in the table 7.

Table 7. Total Produced, Imported and Forecasted Insulations that Contain HBCD in Mongolia 1995-2020 period

Insulation types	In-country produced	Imported	Forecasted to 2021 year	
			Production	Import
EPS	804,405 m3	1,021.7 tons	144,278 m3	60.9 ton
XPS	15,000 m3	255.4 tons	22,500 m3	16.8 ton
Concrete- polystyrene	573,750 m2	-	184,500 m2	-

All above HBCD contained insulations that will be a part of buildings will be starting to be demolished and disposed within 20- 60 years from now on. However, it is a problematic to predict how long a particular building will serve and when to decide in demolishing and there are many factors that lead to demolishing decision of a particular building.

For instance, a building with ten story in UB was demolished even though it was about 10 years old and the reason was the owner wanted to make it more fashionable and attractive. According to demolishing statistics of this 10 story building, 3 tons of plastics and EPS panels were generated during demolishing process.

According to the baseline report of the Solid Waste Modernization Project (2015), construction waste growth is projected by 50% increase in average from 2015 to 2030 in Ulaanbaatar city, taking into account three growth rates: low growth (1%); medium growth (3%) and high growth (5%).

NATIONAL MANAGEMENT ON HBCD IN INSULATION MATERIALS AND WASTES GENERATED FROM CONSTRUCTION AND DEMOLITION

There is currently no specific national regulation exists for HBCD containing import products, its in-country production and its waste disposal.

Mongolia ratified the Stockholm Convention on Persistent Organic Pollutants in 2004 and approved its National Implementation Plan in 2006 [24]. Following these actions, national inventory of POPs and an Update of the National Implementation Plan have been taken in 2012 and 2014 respectively. However, neither PoPs inventory nor updated NIP paid proper attention on HBCD containing construction insulation production, product applications and its disposal fate in the country.

Regarding the waste disposal management within the country, regulatory framework for solid was management is summarized below:

Environmental Protection Law of Mongolia (1995)

The purpose of this law is to regulate relations between the state, citizens, business entities and organizations in order to "guarantee the human right to live in a healthy and safe environment." Waste management is covered briefly within the Environmental Protection Law of Mongolia placing responsibilities on the various administrative divisions within Mongolia and also setting out rights of Mongolia's citizens with regards to access to waste management services.

Renewed Law on Waste Management (2017)

The Renewed Law on Waste Management was adopted on 12 of May, 2017 [13] that reviewed and that include the most of chapters of the Law on Solid Waste Management of 2012 and incorporated entire toxic hazardous waste management issue that was as standalone law before. The principle difference from the previous law is that it emphasizes recycling, regeneration, reuse, of waste in terms of economic benefits and efficient use of natural resources. Especially, it paid a good attention on construction waste through broadly identifying its definition and responsibilities;

The purpose of the Mongolian Law on Solid Waste Management (2012) was to "regulate relations arising from prevention from and reduction of negative impacts of waste on public health and environment, reduction, sorting, collection, transportation, storage, reuse, recycling regeneration, elimination, and export of waste, obtaining economic benefits from waste for efficient use of natural resources, improving public knowledge on waste and prohibition of import and cross-border transportation of hazardous waste."
The Mongolian new Waste Law defines: "construction waste" shall mean waste generated from: construction, renovation and demolition of buildings and substructures; construction and repair of auto roads; construction and maintenance if pedestrian pathways and green facilities; construction and maintenance and replacement of pipelines and engineering facilities; production and trade of construction materials;

With regard to construction waste management, the State Central Administrative Body-Ministry of Construction and Urban Development Matters is required to develop regulations relating to construction waste management [13].

Regulation on Funding of Waste Management and Transportation Operations and Consolidation of Waste Management Service Fees (2015)

This regulation controls waste management activities connected to municipal solid waste emanating from domestic premises and commercial entities [25]. It is not intended to apply to hazardous waste or wastes from the construction industry.

In Mongolia, the construction waste is loosely regulated and poorly monitored. In particular, there is no specific legal documentation for construction waste management. The Ministry of Environment and Tourism has in the past emphasized the issue of construction and demolition waste as environmental hazard and the need of addressing as a priority. However, no constructive activities have been followed so far.

Procedure for transporting construction waste to landfill site

Currently the only legislation or regulation related to construction waste management in Mongolia is the Resolution No. 94 "Procedure for transporting construction waste to landfill site" approved by the Presidium of the UB City Council in 2012 [25].

General Information on Buildings of Ulaanbaatar City

Collecting information about the exact number of the buildings and its characteristics is one of the biggest challenge in Mongolia. This is mainly due to the lack of a digital database and the difficulty to obtain information from some Governmental Agencies.

According to the Baseline study on CDW 2016 [26], it provides information about the number of buildings for each districts by year built in Table 8.

Table 8. Building ages and the numbers of Ulaanbaatar City

Districts	Built before 1941	Built during 1961-1974	Built during 1973-1987	Built during 1987-2000
Bayangol	20	3	130	108
Bayanzurkh	22	41	33	51
Sukhbaatar	23	6	56	40
Songino khairkhan	5	19	41	40
Chingeltei	72	37	85	35
Khan-uul	22	67	15	36
Nalaikh	30	10	18	11
Total	**194**	**183**	**378**	**321**

UB is a relatively young Capital with about 100 years of urbanization, therefore each predominant construction style corresponds to a period in its history. An important classification is provided in Figure 9, where different buildings are divided by the year of construction [27].

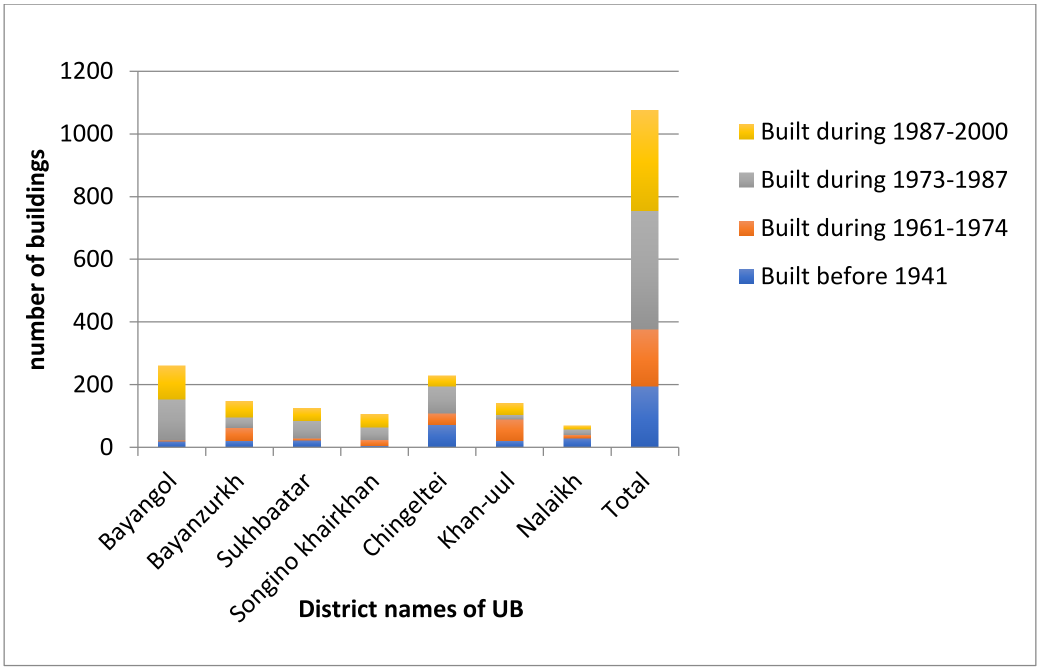


Figure 8. Different buildings are divided by the year of construction

Construction and Demolition Sites

UB is facing an important transformation in the last years and number of construction sites has started to increase again after a small interruption during 2013-2015. The following Figure 4 shows the number of construction sites for each district [28].

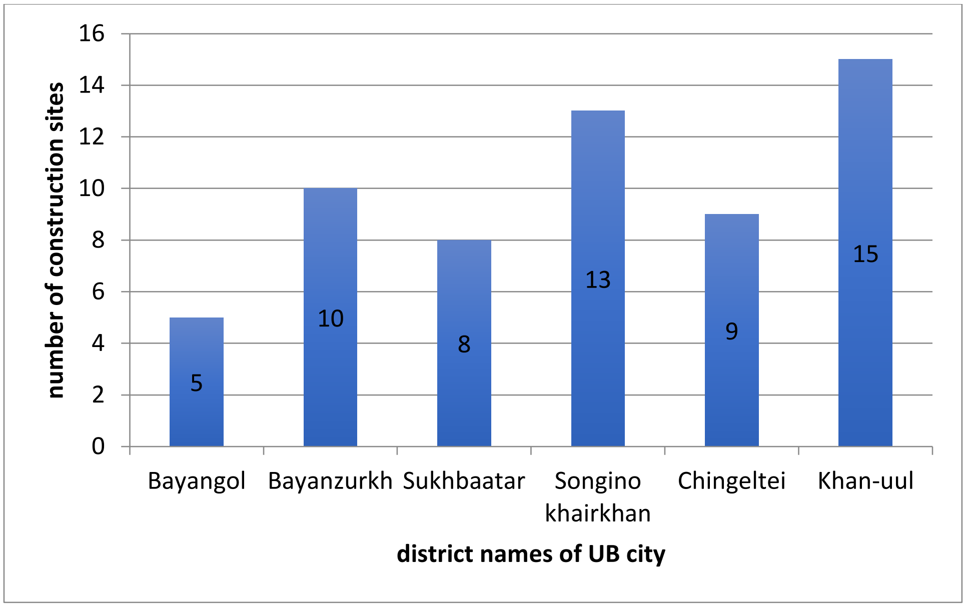


Figure **9**. The number of construction sites for each district in Ulaanbaatar city

With regards to the future demolition project, in 2014, the City Municipality published a list of 324 buildings to be demolished in 2016, the State Inspection Agency published a list of unapproved 97 buildings.

The density location of the buildings planned for demolition is an important base information to plan construction waste management when the demolition activities start. Based on the density of the buildings and their location, it is possible to predict the amount of waste to be expected at nearest landfills, and possibility of illegal disposal.

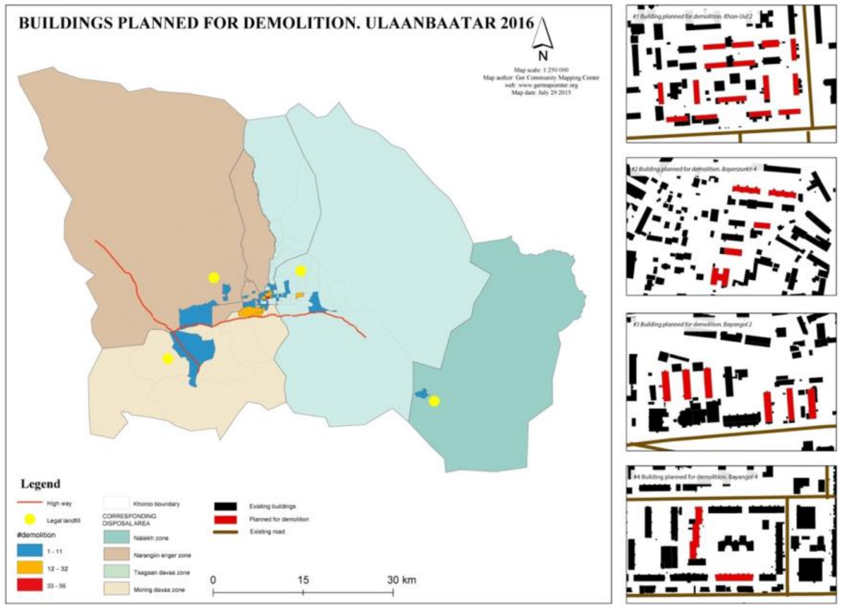


Figure **10**. Buildings planned for demolition, Ulaanbaatar 2016

Current CDW management

Ulaanbaatar (UB), the capital city of Mongolia, is one of the cities facing unprecedented consequences of rapid population increase coupled with economic growth and lack of proper regulations in place. A little over 40% of the total country's population resides in this city. A large part of this population resides in informal settlements, "ger districts", which lack basic infrastructure. The municipal solid waste management (MSWM) of the city is facing critical challenges, making it one of the most pressing issues concerning public health, the environment, and resource efficiency [28]. However, there is insufficient peer-reviewed literature describing the system and providing enough details with reliable data to form the basis of decision making for UB's waste management.

There is no proper solid waste management practice in Mongolia and this creates a lot of problems on the environment and human health.

CDW management encompasses collection, transporting, storage, treatment, recovery and disposal of waste. It can be characterized as comprehensive, integrated, and rational system approach towards achievement and maintenance of acceptable environmental quality and support of sustainable development.

Waste management in the UB city is facilitated by the city municipality. Collection services are operated through a mixture of direct services and sub-contracts with service providers.
Solid Waste is normally disposed in one of the three landfill sites :

- Narangiin Enger Disposal Site (NEDS), a sanitary landfill
- Morin Davaa Disposal Site (MDDS) with limited engineering or management
- Tsagaan Davaa Disposal Site (TDDS) with limited engineering or management

Waste collection is provided at district level by waste transportation organizations known as "TUK". TUK organizations provide collection services for both commercial and domestic premises. Construction waste is typically collected and disposed by construction companies or through direct contracting with waste collection companies or via private truck owners.

In Narangiin Enger, there are operating two types of entities on waste processing: Ulaanbaatar Waste Recycling Plant (UBWRP) and Narangiin Waste Collection Unified Site (NWCUS). UBWRP has been established with support of Republic Korea in 2013 and receives solid waste only from residential houses/apartments of UB city and separates into recyclables and end-disposals. This end-disposals goes into landfill. Its processing capacity is 160 ton/day. UBWRP operates under private company and it is the only recycling plant in Mongolia [28].

NWCUS operates under the UB municipality management and receives all sorts of solid wastes from TUK and entities and citizens without any restrictions. The only requirement for receiving the waste from any sources is to get registered on the entrance. Recycling is mainly a back end process with recyclables of economic value targeted by groups of waste pickers operating at in NWCUS's landfill site.

Waste Quantities

Total amount of solid waste generated in UB, in the period 2013 – 2014, has remained stable around 1 million tones per year and amounts decreased in subsequent years, which the consultant assumes, due to reduced economic activity in recent years [26]. The exact quantities can be seen in Table 9.

Table 9. Total amount of Solid Waste in UB

Year	Total amount of Solid Waste in UB (tones)
2013	1,099,395
2014	1,091,478
2015	969,100 [754,784*]

2016	988,404

Remarks*- official figure in brackets provided by the City service department on 2015 was unusual low and a responsible person could not explain reasons of such a reduction in waste disposal compared to other years. Therefore, it is assumed that once there are no considerable social and economic reasons (like structural change within the waste management organization, increased or reduced waste collection/transporting capacity, workers strike or sharp economic crises among city inhabitants etc.) behind this number, it might be of a common mistake. Because of this, 2015 waste disposal data used in recent study of Bolorchimeg et, al. 2017 is applied for this case. (Source: Bolorchimeg Byamba and Mamoru Ishikawa. Municipal Solid Waste Management in Ulaanbaatar, Mongolia: Systems Analysis. Journal Sustainability 2017, 9,896; doi:10.3390/su9060896;)

Waste Generation and Composition

According to the 2015 data, the total amount of all waste registered at all three landfill sites was 969.1 thousand tones (Figure 6 showing all the waste categories) arriving at NEDS, TsDDS and MDDS with the proportions 47%, 36.8% and 16.2%, respectively. MSW includes waste from household (apartment and *ger*) and streets and public spaces that accounts for 53.9% of total waste registered at weighbridges. MSW generation of UB city is 1.12 kg per capita per day (408.82 kg per capita per year). This number should be considered as the minimum, since recyclables are extracted in the stages prior to disposal.

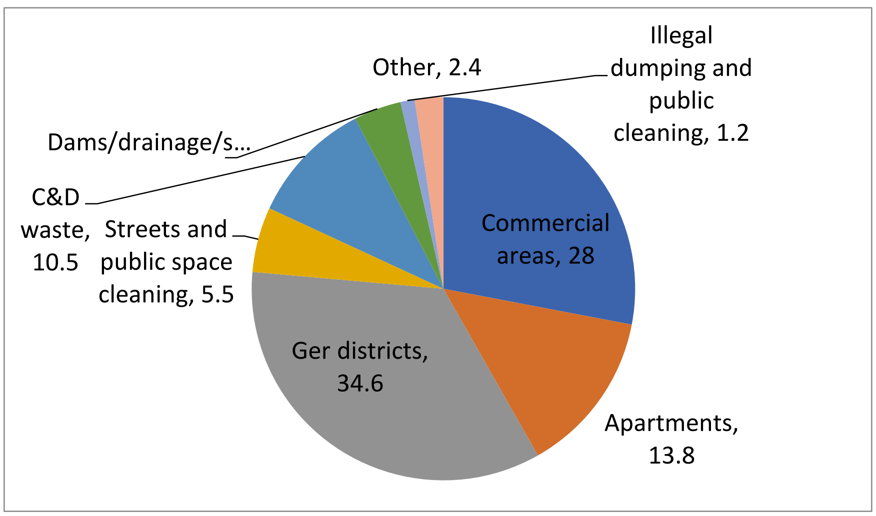


Figure **11.** Composition of waste registered for disposal at landfill sites in 2015.

Over 90% of waste quantities go to the aforementioned landfills, each servicing waste from the city's six central districts: Bayangol, Bayanzurkh, Songino-Khairkhan, Sukhbaatar, Chingeltei and

Khan-Uul, including commercial, industrial and domestic wastes.

Narangiin Enger Waste Landfill Site is the biggest waste landfill site in UB, which is located in northwest of UB.

The landfill treats 1200 ton waste per day. It was said that the capacity of this landfill is limited and will exceed its capacity in 2020. Design period of Narangiin Enger Disposal Site (NEDS) is 10 years which ends in 2020 but it might be shorter due to increase of waste generation amount. The types of waste are mainly paper, plastic and soil waste from domestic households. A workshop is located at the bottom of the landfill, which was constructed by Korea. They collect recyclable waste and classify this waste into glass, bottle, plastic and bone. After that, most of these are exported to China as resources to be used in industry [26].

The amount of solid waste in tonnes in each landfill site for the period 2013-2016 is presented in Table 10. Data for 2015 is limited to the first part of the year (January to August).

Table 10. Figures related to the solid waste generation in UB landfill sites

Landfill site	Solis waste generation in UB landfill sites (tonnes)			
	2013	2014	2015	2016
Narangiin Enger	591,991	557,962	455,477	429,262
Tsagaan Davaa	401,796	380,596	356,629	395,285
Morin Davaa	105,608	152,920	156,994	163,856
Total	1,099,395	1,091,478	969,100	988,404

The typical process on the landfill site is described below:

- Truck arrives and drives up onto the weight scale;
- The site employee inspects the content of the truck;
- The driver indicates the source District and Khoroo;
- The site employee records the weight, driver's name and plate number;
- The information is registered in the Waste Registration System;
- Receipt is given to the driver;

Tsagaan Davaa landfill located in Bayanzurkh district reported that on average they receive 400 trucks per day, and about 20% accounts to construction waste. This landfill, is officially operational 24 hours over 7 days. However due to lack of lighting in the area, trucks are not allowed to get into the landfill site (to prevent accidents). This is an important factor, leading to illegal disposal of waste, especially when construction waste is often hauled during night time.

It is reported that during 2006 to 2014 the amount of CDW has increased by a factor of six. According to the Ministry of Environment, on average, the CDW generated in UB is about 80 thousand tonnes per year. It should be noted that the estimation of total amount of construction waste is highly problematic, and figures proposed by different authorities show significant discrepancy. A joint baseline study conducted by the City Municipality together with the European Bank in 2015 estimates about 90 thousand tonnes per year. The figures of last two years obtained from the unified waste disposal management authority [29] confirms Ministry of Environment estimates of 80 thousand tonnes.

Table 11. Construction Waste Volume of Last Two Years

Construction waste volume in last two years in kilotonnes and %				
	2015		2016	
	In kilotones	%	in kilotonnes	%
NEDS	26,792	8.19	17,818	4.15
TDDS	11,448	3.67	34,561	8.74
MDDS	35,926	31.07	28,373	17.32
	74,166		80,752	

The city municipality reports the percentage of CDW accounts to about 10- 15% of all waste generated city-wide but another source estimates CDW to be 40% of all waste by mass. The amount of CDW varies from year to year, and the trend is on the increase.

Since a significant amount of CDW comes from demolition of the buildings, the total CDW amount can differ significantly among years based on intensity of demolition activity.
Statistics show that the amount of CDW is booming every year in months March-October

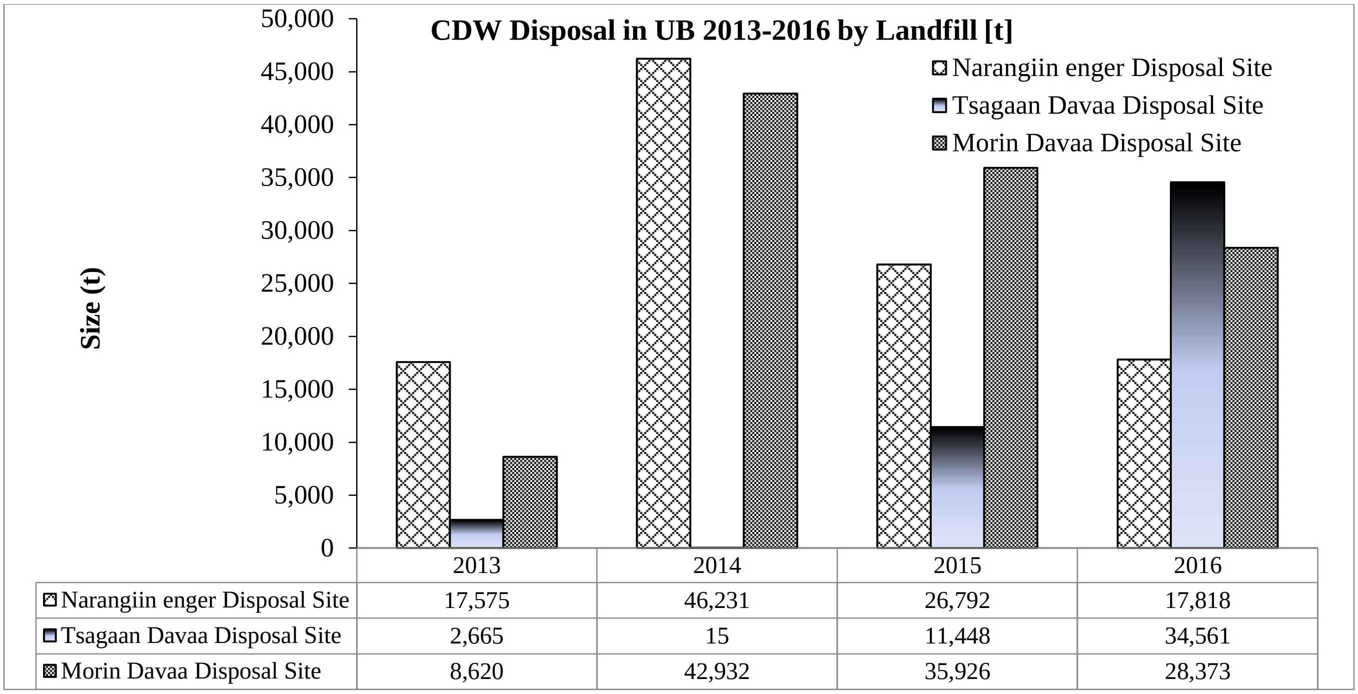


Figure **12**. Construction Waste at Disposal Sites in tone.

Table 12 shows the detailed amounts in tonnes of CDW from each of the districts of UB [30].

Table 12. Tones of CDW amount from each district of UB

District name	2013	2014	2015	2016
Baganuur	4	36	31,860	-
Bayangol	3,862	11,435	14,618	8,095
Bayanzurkh	1,269	1,887	4,800	25,874
Sukhbaatar	569	1,648	1,471	5058
Songinokhairkhan	-	25,747	11,127	9,035
Khan-Uul	10,189	47,549	33,300	31,336
Chingeltei	370	874	529	1,354
total	16,263	89,176	65,864	80,753

Based on discussions with the local construction industry [15], the waste management techniques for residual waste from construction activities is via one of the following four ways.

- *Disposal at the construction site*

Construction waste may not leave the construction site. Typical disposal options include on site burial of waste within the construction site.

- *Disposal at UBC landfills*

There are records of approximately 80,000 tonnes of CDW entering the three UBC landfill sites. It is difficult to determine the proportion of the total CDW this represents in total due to the unofficial disposal practices occurring in the industry.

- *Private Collections*

Based on the interviews taken during the field trip in UB, in some cases construction waste is scavenged from larger construction projects and used by individuals in the construction of small dwellings in the Ger areas.

- *Illegal dumping*

Backfilling off vehicles delivering materials to site is a common approach to waste collection in the construction industry in UB. This approach utilises the empty vehicle whilst offering additional revenue for the driver. It is understood that much of this work is done on an informal "cash-in–hand" basis and may be executed without the knowledge of management from either party (e.g. construction company or transport company).

Illegal dumping represents a serious problem in UB, about 20% of all waste generated in the city is illegally disposed (Figure 14 and 15). The numbers from all three official landfills in 2015 reports 80,753 tonnes of construction waste registered. It is reported that the city municipality spent 200 million Tugrugs to clean up illegal CDW in 2011.

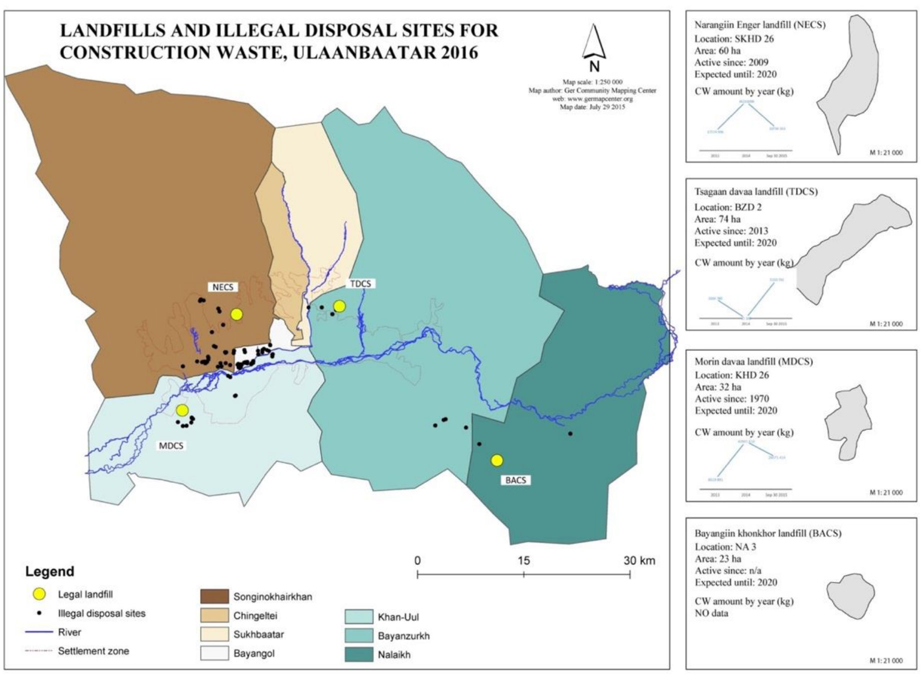


Figure 13. Legal and illegal disposal sites in UB area

Figure **14**. Example of illegal disposal of construction waste in UB area.

Demolition information

With increasing urbanization and greater demand for housing and offices in the cities, as well as significant demolition of old buildings to make way for modern ones, there are currently many opportunities for construction and demolition companies in Mongolia.

A most part of the construction and demolition work is done by small and medium-sized contractors and subcontractors [27]. Thus, SMEs are producing much of the CDW. Their unsustainable approaches are having negative impacts on human health and the environment in Mongolia.

The problem is that the SMEs involved in construction and demolition have no knowledge or human resource capacity regarding how to manage waste according to the Reduce, Reuse, Recycle (3Rs) and life-cycle approaches. Also, there are no certified companies in Mongolia with experience in safe demolition processes that preserve usable materials at demolition sites.

All the demolition work is performed following the traditional methods by contractor and sub-contractor with experience only in construction activities. There are regulations and codes which determine if it is necessary to demolish a building.

Demolition can happen when:

- The condition of the building has become out of use as a result of natural phenomena and other factors.
- The building is found as impractical and dangerous by professional organization.
- The structure is defined as economically inefficient by technical assessments.
- The owner decides to demolish it.

The relevant authority issues building demolition technical assessments based on the following related legal documents, codes and regulations [13]:

- "Construction codes on construction planning at seismic zones of Mongolia" CCN 22.01.01*/2006.
- "Instruction for assessing earthquake resistance rate of existing building" CR 31-102-00.
- "Methodological instructions on certification to existing building in seismic zones" CR 31-103- 00.
- "Estimation manual of residential buildings physical deterioration" CR 31-104-01.
According to 25.2.1, 25.2.2, 25.2.3, 25.2.4, 25.2.5, 25.2.6, 25.2.7, 25.2.8, 25.2.9, 25.2.10 of the Article 25 of Mongolian Law on Construction, condemned as required to demolish by Specialized Inspection Agency.
- According to 26.1.1 of Article 26 of Mongolian Law on Construction, official statement of demolition is issued.
- "Methodological instructions for assessing requirements for residential buildings" approved by Decree No.322 by the Minister of Road, Transportation, Construction and Urban development, 2011.

However, the government needs to establish a comprehensive system for CDW management, including capacity building of SMEs working in the demolition sector, providing legal guidelines on CDW management and procedures for certification of SMEs and compliance monitoring [31].

CURRENT STATUS OF HBCD CONTAINED INSULATION WASTE RECYCLING AND DISPOSAL

As per 2016 data, there are numerous recycling factories exist in Mongolia [15]. However, there is no insulation material recycling and separation facility in Mongolia to date.

Number and types of recycling factories available in Mongolia are shown in figure 16.

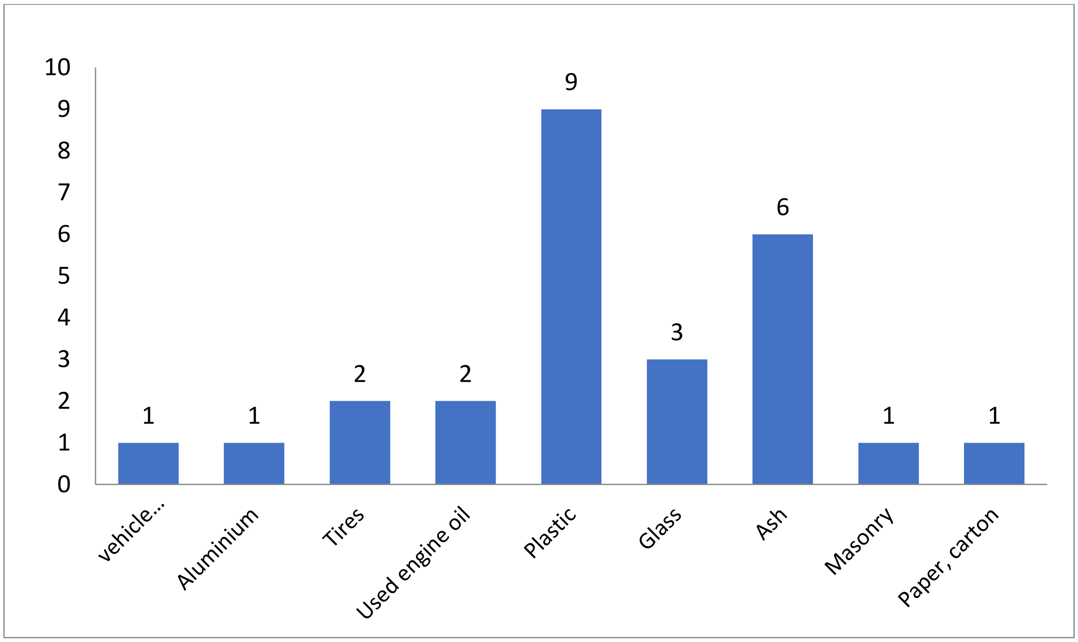


Figure **15**. Number of recycling factories and types of recyclables in Mongolia

As the figure 16 shows, recycling factories are quite limited in their recyclables.

There no established mechanisms nor structures exist for construction waste separation and recycling of insulation that contain HBCD in the country to date.

Neither decision makers nor constructors and waste managers aware about environmental and health consequences of HBCD contained insulation materials and its waste in the country to date.

While there is a potential high risk of polluting of surrounding environment and deteriorating public health with HBCD contained insulation waste in upcoming years, the government needs to immediately related procedures for managing CDW with HBCD, work on public and business awareness raising to avoid further consequences. Also, the government need to inform as soon as possible SMEs working on importing and production of HBCD contained building insulations and waste recyclers about the Stockholm Convention's ban on HBCD ban as well as its possible alternatives before 2021.

CONCLUSION

On HBCD contained insulation production and consumption

Currently there is a lack of awareness among decision makers and general public on negative impacts and consequences of HBCD contained products for public health and environment.

Neither insulation producers nor regulators aware about the proposed ban on HBCD contained insulation production by 2021. No national legislation exists to regulate HBCD containing insulation production and imports in Mongolia.

There is a lack of data to properly assess volume of HBCD contained insulation, annual production, related application on construction sectors.

On CDW in general and HBCD contained waste, in particular

In Mongolia, like other developing countries, the major barriers in CDW management can be summarized in:

- Lack of awareness on HBCD contained CDW waste specifics its posed risks to health and environment
- Lack of awareness and culture regarding waste management by Government agencies.
- Lack of support and human resources from key stakeholders such as Inspection Agency, which is main government body for environmental and health legislation compliance monitoring.
- Lack of incentives from construction regulatory authorities and low costs of sending materials
- to landfill.
- Lack of community attention on CDW management

However, one of the major factors to effectively handle waste in the construction industry is achieving the governmental support.

On CDW practice

- CDW sector is at its infant stage in Mongolia
- There is lack of clear regulation and government lead support for private sectors to be involved in CDW management
- Demolition activity is not followed by the separation of CDW because companies have no

- incentives to perform this task.
- Construction companies do not collaborate with recycling companies, most of the time they are not aware of the existence of recycling sector in Mongolia.
- No certified company exists to perform a safe demolition and there is no specific regulation which addresses this problem.
- No policy is required for designers/contractors to use a suitable portion of recycled aggregates in construction project.
- Lack of a database for the buildings of UB create a big obstacle to a clear understanding of the quantities of CDW produced after a demolition.

RECOMMENDATION

The Government of Mongolia (GoM) – the main regulator – needs to proactively propose follow up actions to amend legislations related to Persistent Organic Polluters in particular, Hexabromocyclododecane (HBCD) contained production and import limitation as well as provide clear guidance on HBCD substitutes emerging in the international markets to assist local businesses to re-orient their business and technologies as early as possible before the enacting HBCD ban.

GoM needs to improve statistical procedures related with registration of goods import especially, chemicals; volumes of all types of construction products for making a sound management policy and regulation.

Mongolian Government has to provide a uniform national approach to waste minimization and create regulations and building codes to mandate CDW management. In particular, GoM needs to amend its new law on waste as well as strengthen construction waste regulation in a view on HBCD contained insulation waste separation, proper handling, storage and disposals. It needs to encourage business entities to involve into DCW separation and wider application of reduce-reuse-recycle principles for waste minimization for any types of waste, including HBCD contained insulation waste.

Mongolia also needs to fulfill country's obligations to treat HBCD containing materials in accordance with the Stockholm Convention Article 6.

It is recommended that Mongolia needs to seek and adopt international best practices on HBCD handing policy and application through bilateral or multilateral cooperation

It is encouraged Basel and Stockholm conventions' support to assist Mongolia in establishing national capacity for proper handling of HBCD related registration systems, elaborating or strengthening its green policies to incorporate HBCD issues, including awareness raising of decision makers, business entities and general public for HBCD and other emerging chemicals and PoPs.

REFERENCE

1. Consultancy Agreement between BCRC China/SCRCAP and Erdenesaikhan, consultant based in Mongolia
2. Terms of Reference for conducting a study on HBCD
3. https://data.worldbank.org/country/Mongolia
4. https://mcud.gov.mn/documents/
5. National Statistical office. Construction Sector Statistics 2015
6. Introduction to Building Insulations. Training handbook. Darkhan-Urguu Polytechnical College 2015 in Mongolian
7. EPS/XPS producers' data provided by the Mongolian Association of the Construction Materials Producers, 2017
8. Personal communications of Erdenesaikhan and interview with Insulation Producers (Ms. Tsetsgee and others), 2017 and 2018
9. Updated data on EPS/XPS producers provided by the Mongolian Association of the Construction Materials Producers, 2018
10. Tradeingeconomics.com, 2018
11. www.1212.mn of the National Statistical Office 2018
12. www.estandard.mn
13. www.legalinfo.mn
14. National Ozone Office, Ministry of Environment and Tourism, 2017
15. Somayeh Lotfi and Tommaso Troiani, Technical University Delft. Baseline Study on Construction and Demolition Waste Management. 2016 "Improving Resource Efficiency and Cleaner Production in the Mongolian Construction Sector through Material Recovery Project". Client: Caritas Czech Republic in financial support of European Commission and Czech Republic Development Cooperation- 47 pages;
16. Insulation import data between 1995-2017 obtained from the Statistical division of the General Customs Department, August 2017
17. World Economic Forum Global Enabling Trade Report 2014, p11.
18. Quarter Report of AsiaFoundation, Ulaanbaatar city Nov. 2015
19. Quarter Report of Asia Foundation, Ulaanbaatar city Jun. 2015
20. https://www.business-anti-corruption.com/country-profiles/mongolia
21. https://www.adb.org/countries/mongolia/economy
22. https://tradingeconomics.com/mongolia/forecast
23. World Bank Global Economic Prospects -- January 2018 -- Economic outlook for East Asia and Pacific region, 2018
24. Environmental status reports 2006-2010, Ministry of Environment and Tourism of Mongolia
25. Legal documents of the Ulaanbaatar City Governor Office, 2017

26. Final Report "Strengthening the Capacity for Solid Waste Management in Ulaanbaatar Ctiy" Sep 2012, Japan International Cooperation Agency (JICA) Project Team for SWM in Ulaanbaatar City Kokusai Kogyo Co., Ltd. MG JR 12-003.- 64 pages;
27. Somayeh Lotfi and Tommaso Troiani, Technical University Delft. Study of the Mongolian Context and CDW Recovery Applications. 2016. "Improving Resource Efficiency and Cleaner Production in the Mongolian Construction Sector through Material Recovery Project". Client: Caritas Czech Republic in financial support of European Commission and Czech Republic Development Cooperation- 72 pages;
28. Baseline Study Report. ERM Japan Co., Ltd. Nov 2015. Ulaanbaatar Solid Waste Modernization Project Feasibility Study. Prepared for European Bank of Reconstruction and Development and with support from Japan-EBRD Cooperation Fund- 77 pages;
29. Bolorchimeg Byamba and Mamoru Ishikawa. Municipal Solid Waste Management in Ulaanbaatar, Mongolia: Systems Analysis. Journal Sustainability 2017, 9,896; doi:10.3390/su9060896;
30. Waste Entrance Data at Three Main Disposal Sites obtained from UB Waste Service Department, August 2017
31. UB Waste Management Improvement Program 2013-2016, Ulaanbaatar Municipality, 2017

APPENDIX

1. Consultancy Agreement between BCRC China/SCRCAP and Erdenesaikhan, consultant
2. Terms of Reference for conducting study on HBCD

Management Plan on HBCD and its waste in Korea (Republic of)

2018. 3.

Seung-Whee RHEE

KGU Kyonggi University

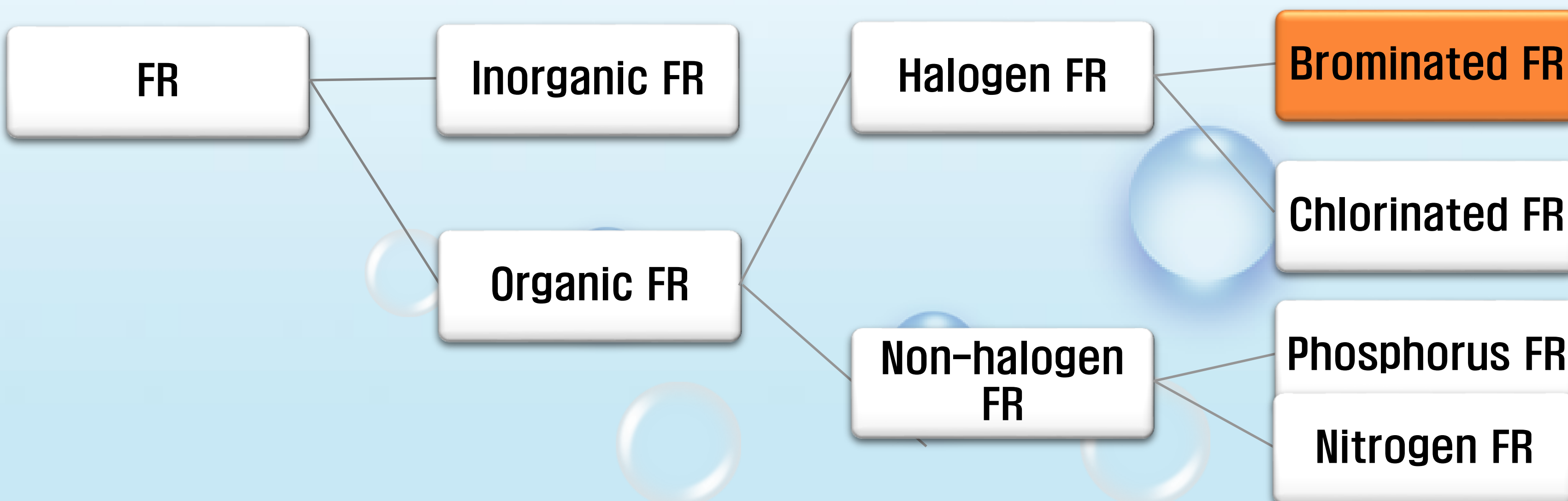
Contents

Introduction

- Petrochemicals : widely used (synthetic resins, fibers, rubber, etc.)
  → Easy to manufacture. Mass production system is established.

- Petrochemicals have a high risk of fire when heat is applying .
  → Added Flame Retardant [FR]

- Among FR, Brominated Flame Retardants [BFRs] account for about 40% of the global market with low price and high flame retardant effect.

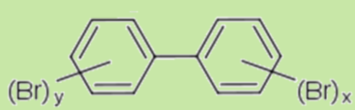
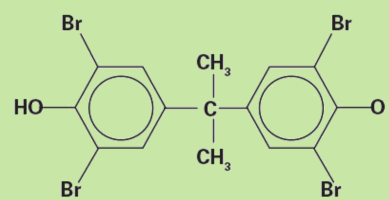
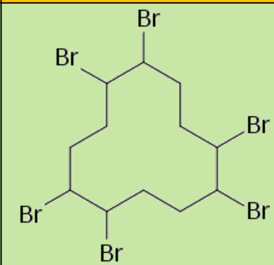
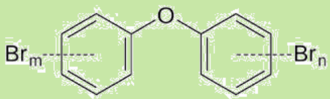


Introduction

- The BFRs are widely available in several hundreds of types, including Polybrominated diphenyl ethers (PBDEs), Polybrominated biphenyls (PBBs), Hexabromocyclododecane (HBCD), and Tetrabromobisphenol A (TBBPA).

- The BRFs are excellent in versatility and economical efficiency, but may adversely affect human health and the environment.

- Toxicity of major BFRs

Type	PBDEs	TBBPA	HBCD	PBBs
Structure				
Cas No.	-	79-94-7	25637-99-4	-
Toxicity	Possibility of neurotoxicity and carcinogenesis	Found in breast milk and potentially hepatotoxic	Bio-concentration, neurotoxicity	Hypothyroidism, hepatic / renal toxicity

Source: BFR in Dust on Computers (THE CASE FOR SAFERCHEMICALS AND BETTER COMPUTER DESIGN), 2004.




Introduction

- Stockholm Convention
  → 4th COP (2009) : PBDEs are listed in the Annex as substances to be controlled.
  → 6th COP (2013) : Decided to add HBCDs in the Annex.

- The Basel Convention provides the information for BFRs, including technical guidelines for treating waste containing BRFs.

- In the EU, BFRs including HBCDs are restricted for use in accordance with WEEE Directive and RoHS, etc.

- As a party to these Convention, Korea tried to manage the waste containing BFRs according to the guideline of Basel Convention, RoHS, WEEE and ELV Directive.

- Management plan for HBCD including regulatory Levels and test method will be established Shortly.




Objectives of Study

Purpose

Perspective on Management of HBCD waste in Korea

Regulations for BFRs in Korea

- Regulations for waste-containing BFRs in Korea
- Regulations for baby products

Status of Waste contaminated with HBCD in Korea

- Usage of HBCD in Korea
- HBCD-containing Waste in Korea

Perspective on Management of HBCD in Korea

- Regulatory Levels of HBCD in Korea
- Test Method of HBCD in waste

II. Regulations for BFRs in Korea

Regulations for BFRs in Korea (Republic of)

Regulation	Department	Major content	Note
Chemical control act	Ministry of Environment	- Designation of hazardous substances - Pollutant Release and Transfer Register (PRTR) system	- Included 6 types of BRFs - Only Deca-BDE is managed in PRTR.
Act on Registration, Evaluation, etc. of Chemicals (AREC)	Ministry of Environment	- Designation of hazardous substances	- Included 6 types of BRFs
Persistent Pollutants Control Act	Ministry of Environment	- Designation of persistent organic pollutants	- Included 6 types of BRFs
Act on Resource Circulation of Electrical and Electronic Equipment and Vehicles	Ministry of Environment	- Restriction on the use of hazardous substances in electrical and electronic products	- 27 types of e-waste - Included 6 types of BRFs (PBBs, PBDEs)
Electrical Appliances Consumer Products Safety Control Act	Ministry of Trade, Industry and Energy	- Types of products subject to safety control	- Conducted hazard assessment according to AREC

Type of BFRs in Korean Regulations

Regulation	Target chemical substance (Cas. No.)
Chemical control act (6 types)	Octabromodiphenyl oxide (32536-52-0), Pentabromodiphenyl oxide (32534-81-9), 1,2-Dibromoethane(106-93-4), Polybrominated biphenyls; PBBs (59536-65-1), Tris(2,3-dibromopropyl)phosphate(126-72-7), 2,3-Dibromo-1-propanol(96-13-9)
Act on Registration, Evaluation, etc. of Chemicals (6 types)	
Persistent Pollutants Control Act (6 types)	Tetrabromodiphenyl ether (–), Pentabromodiphenyl ether (32534-81-9), Hexabromodiphenyl ether (–), Heptabromodiphenyl ether (–), Hexabromobiphenyl (–), Hexabromocyclododecane; HBCD (–)
Act on Resource Circulation of Electrical and Electronic Equipment and Vehicles (2 types)	Polybrominated biphenyls; PBBs (67774-32-7), Polybrominated diphenylethers; PBDEs (–)
Electrical Appliances Consumer Products Safety Control Act (4 types)	Polybrominated diphenylethers; PBDEs (–), 1,2-Dibromoethane (106-93-4), Tris(2,3-dibromopropyl) phosphate (126-72-7), Polybrominated biphenyls; PBBs (59536-65-1)
Special Act on the Safety of Products for Children (4 types)	
Food Sanitation Act	-

Regulations for baby products

- Baby may be sensitively affected by products contained chemical substances such as HBCD.
- The regulations for baby products containing brominated flame retardants (BFRs) are as follows.

Regulations related to Baby products	Act	Scope
	Special Act on the Safety of Products for Children	List of children goods subject to safety management
	Environmental Health Act	Risk assessment for the baby products
	Food Sanitation Act	Table ware, Baby bottle, etc.

List of BFR in Risk Assessment of Environmental Health Act

Hazardous substances	CAS No.
Polybrominated diphenylethers (PBDEs)	-
1,2-Dibromoethane	106-93-4
Tris(2,3-dibromopropyl) phosphate	126-72-7
Polybrominated biphenyls (PBBs)	59536-65-1

Standards for containers (Table ware, Baby bottle, etc.)

Hazardous substances	Standard (ppm)
Bisphenol A	0.6
Di-(2-ethylhexyl) phthalate (DEHP)	1.5
Di-n-butyl phetalate (DBP)	0.3
Benzylbutyl phethalate (BBP)	30

* Ref. article 7(1) of the Food sanitation act, 2016.

In Korea, HBCD needs to be added in the Act

III. Status of Waste contaminated with HBCD in Korea




The Status of Use for BFRs in Korea (2013)

- According to the result of the Korea Chemical Management Association in 2013, 17 kinds of BRFs were used in Korea.
- HBCD has 16 isomers. Two of them were used in Korea such as CAS No. 3194-55-6 and CAS No. 25637-99-4.
- Identification of HBCD

CAS No.	Identification of HBCD
3194-55-6	This number refers to 1,2,5,6,9,10-HBCD and is thus the most correct one from a chemical point of view
25637-99-4	This number refers to HBCD (without specifying the bromine positions) and is used by some industry for the commercial substance

Ref. European Chemical Agency, Member state committee support document for identification of HBCD and all major diastereoisomers identified as a substance of very high concern, 2008.

The Amount of Use for BFRs in Korea (2013)

Substance group	Substance	Generative name	CAS No.	Import[1) [ton]	Export [ton]	Usage [Final product] [ton]	Stock (ton)
PBDE	Decabromodiphenyl oxide	Deca-BDE, DBDPO	1163-19-5	1,938	127	1,405	406
HBCD (2 types)	1,2,5,6,9,10-Hexabromocyclododecane	HBCD	3194-55-6	1,927	701	1,226	0
	Hexabromocyclododecane	HBCD	25637-99-4	639	197	309	133
TBBPA	Tetrabromobisphenol	TBBPA	79-94-7	28,103	5,680	21,245	1,178
Others[2) (13 types)		-	-	38,530	26,095	12,435	0
Total (17 types)				40,433	32,800	36,621	1,252

1) Includes imports of raw material for synthesis of BFRs
2) CAS No. of others : 84852-53-9, 26265-08-7, 25713-60-4, 40039-93-8, 68928-70-1, 88497-56-7, 135229-48-0, 3278-89-5, 158725-44-1, 21850-44-2, 71342-77-3, 32588-76-4, 52434-90-9

* Ref. Korea Chemical Management Association, Study on the detailed status of the brominated flame retardant in Korea, 2015

The amount of HBCD usage

Large Category	Medium Category	Details	Quantity (ton)	Ratio (%)
Building materials	Insulator	Extruded polystyrene foam	1,412	92.0
		Text product, R&D, etc.	0.3	0.0
Vehicle	Fabric	Car sheet, Door trim	97	6.3
Other uses	Other products	Packing material	16.8	1.1
		Lubricant	0.03	0.0
		The others, R&D	0.002	0.0
Textile products	Curtain	Blind, roll screen	8.6	0.6
Electrical and electronic product	Component	Home appliance	1.1	0.1
Total	-	-	1,536	100.0

* Ref. Korea Chemical Management Association, Study on the detailed status of the brominated flame retardant in Korea, 2015.

The Number of Company used HBCD in Korea (2013)

Industrial Code in Korea	Business classification	Importer	Intermediate manufacture	Final product	Total
13	Textile products manufacturing ;; except clothing	-	-	7	7
20	Manufacture of chemicals and chemical products ; except medicine	3	4	2	6
22	Plastics and rubber products Manufacturing	2	7	79	88
25	Fabricated Metal Product Manufacturing ; except machine, furniture	-	-	7	7
28	Electrical equipment Manufacturing	-	-	1	1
46	Wholesale trade agents and brokers	10	1	1	30
74	Facilities management and landscape services	-	-	1	1
96	Other personal service	2	-	-	2
Total		17	12	98	142

* Ref. Korea Chemical Management Association, Study on the detailed status of the brominated flame retardant in Korea, 2015.

The Content of HBCD in the Building Materials in Korea

Type	Number of sample	HBCDs (mg/kg)		
		Average±Standard deviation	Median	Range
Insulator	21	2,854.7±3,933.7	499.4	N.D. ~ 16,021.3
Paint	3	2.4±2.1	1.5	0.4 ~ 5.3
Walls &ceiling finishes materials	4	11.1±6.3	9.7	4.0 ~ 21.1
Glue	1	0.8±0.0	0.8	0.8
Wall paper	2	0.5±0.5	4.5	N.D. ~ 0.9
Decorative synthetic resin	2	2.1±2.1	2.1	N.D. ~ 4.1
Resist	1	N/D	N.D.	N.D.
Street furniture	2	13.2±1.2	13.2	1.2 ~ 25.2
Recycled materials	9	2,556.3±6,022.5	26.3	0.0 ~ 19,499.3

* N.D. : Not Detected.
* Ref. Ministry of Environment, Survey on BFRs among Building Materials, 2015.

The Content of HBCD in the Automobile Waste in Korea

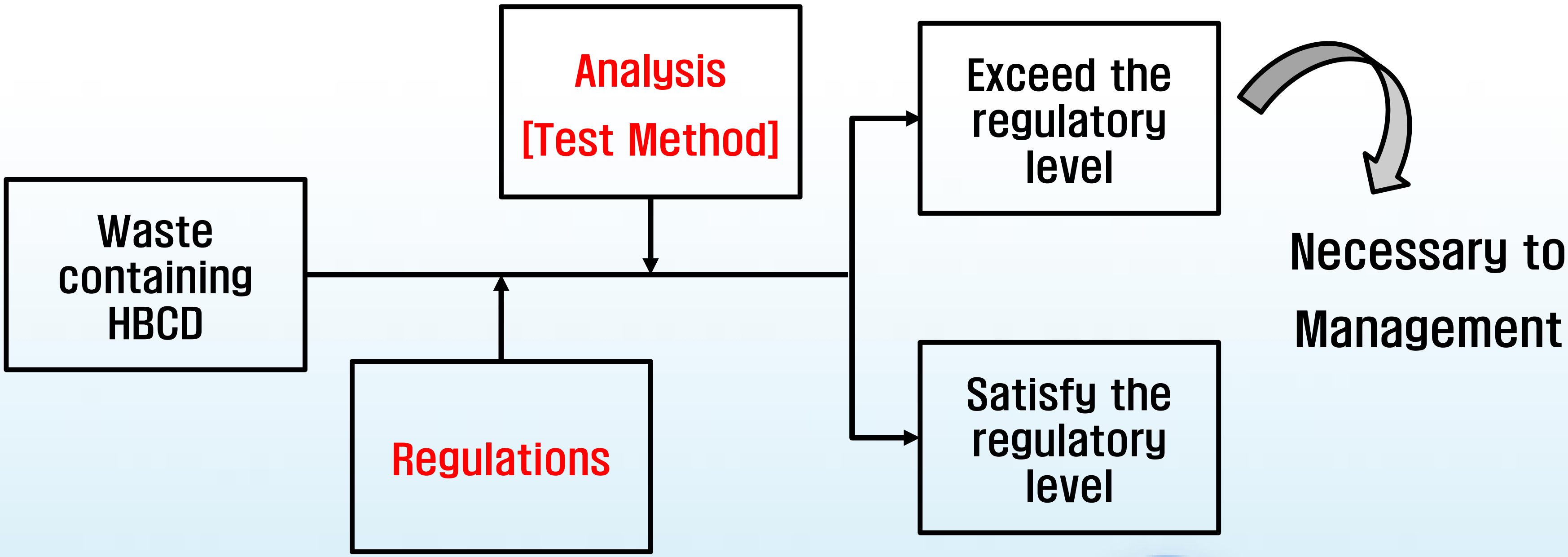
Type		Range of HBCDs (mg/kg)
Part of cars	ceiling (fiber)	N.D.
	Floor (fiber)	N.D.
ELV	ASR	N.D. ~ 167.34
	Sheet form	N.D. ~ 15.35
	Car seat	N.D. ~ 14.84
	Bumper crusher etc. (synthetic resin)	N.D.

* N.D. : Not Detected.

* Ref. National Institute of Environmental Research, Research of proposal content standard for the waste containing new POPs (II), 2016.

IV. Perspective on Management of HBCD in Korea

Tools for the Management of HBCD-containing Waste

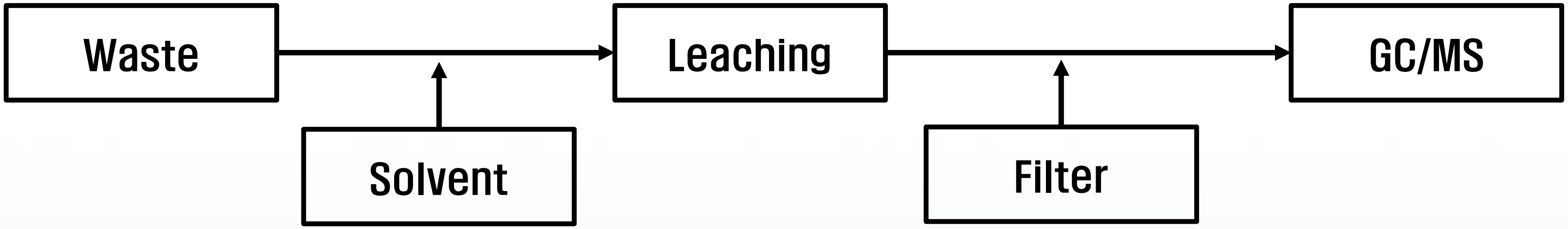


- Regulatory level for HBCD are not established in Korea.
- In Korea, the official test method for HBCD is not legally prescribed.

Regulatory Level of HBCD

Country or Organization	Regulatory Level	Reference
Basel Convention	Provisional definitions of low POP content : 100 or 1,000 mg/kg	Basel Convention COP-13 http://www.basel.int/
Stockholm Convention	Management standards for products : 100mg/kg	Stockholm convention, chm.pops.int, 2015
EU	Presence of no more than 100 mg/kg as an unintentional trace contaminant in substances, mixtures, articles or flame-retarded parts of articles. This is subject to review by the Commission by March 22, 2019	EU Directive 2016/293
EU	Low POP Centration Limits (LPCL) : 100 mg/kg	BIPRO, Study on waste-related issues of newly listed POPs and candidate POPs, 2011
Korea	Content in Product: 100 mg/kg (Draft) Lower concentration limit : 100 mg/kg (Draft) Upper concentration limit : 1,000 mg/kg (Draft)	National Institute of Environmental Research, Research of proposal content standard for the waste containing new POPs (II), 2016.

General Test Method for HBCD



Test Method of HBCD in Research conducted in Korea

Type of waste	Leaching	Solvent	Filter	Reference
Polymer substance	Soxhlet	n-hexane	Syringe filter	KS M 1072 (Determination of TBBPA and HBCD in polymer materials, 2016
Small appliances	Soxhlet, sonicator	Toluene	Multilayer silica gel	National Institute of Environmental Research, Survey on POPs (BFRs) in Waste of Electrical and Electronic Products, 2012
Plastic parts of household appliances	Soxhlet	Toluene	Syringe Filter	Song, M.H., et al., Case Study on Determination of the Level of New RoHS II Substances in Domestic Electronic and Electrical Equipment, Clean Technology, 17(2), 2011
Building materials	Soxhlet, Ultrasonic extraction	Dichloromethane, Toluene, etc.	Syringe filter	Ministry of Environment, Survey on BFRs among Building Materials, 2015

Need for an official test method of




Summary

01

- In Korea (Republic of), BFRs are managed by Regulations, but the regulations governing HBCD are insufficient.
- In particular, regulations for baby products were necessary because baby can be sensitive to chemicals such as HBCD.

02

- In Korea, two types of HBCD (CAS No. 3194-55-6 and 25637-99-4) are used. In 2013, 1,536 tons of HBCD were used in final products.
- HBCD is mainly used in building materials and vehicles.

03

- In Korea, there is no regulation for HBCD, but NIER recommends 100 mg/kg (draft) in waste.
- In this regulation (draft), insulator, recycled building materials among the waste generated from building materials and vehicle are exceeded the regulation (draft).
- It is necessary to establish management plan of HBCD.
- Also, the official test method for HBCD is not established, so it needs to be set up.

Thank you for Your Attention

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