

# The Next Generation of POPs: PBDEs and Lindane

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April, 2005



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**“Keep the Promise, Eliminate POPs!” Campaign and Community Monitoring  
Working Group of the International POPs Elimination Network (IPEN) Report**

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## Executive Summary

The Stockholm Convention on Persistent Organic Pollutants (POPs) is the first global, legally binding instrument whose aim is to protect human health and the environment by controlling the production, use and disposal of toxic chemicals. As ratified, the Convention addresses a “dirty dozen” group of chemicals, primarily pesticides. The Convention recognizes that all POPs-like chemicals, those that stay in the environment for a long time, are poisonous, and build up in living things—pose an unacceptable threat to human health and the environment. The Convention establishes a science-based process for identifying and eliminating POPs worldwide. It also applies the “precautionary approach” by recognizing that there does not have to be absolute, final proof that a chemical is doing harm before action on it is taken.

The International POPs Elimination Network (IPEN) views the Stockholm Convention as a promise to take actions needed to protect the global public’s health and the global environment from injuries that are caused by persistent organic pollutants, a promise that was agreed by representatives of the global community: governments, interested stakeholders, and representatives of civil society. We call upon all Stockholm Convention Parties and stakeholders to honor the integrity of the Convention at the first Conference of the Parties (COP1) in Uruguay.

IPEN has collected chicken eggs from hot spots around the world and analyzed them for the presence of polybrominated diphenyl ethers (PBDEs), hexabromocyclododecane (HBCD), and hexachlorocyclohexane (HCH, lindane). The eggs were obtained from locations near hazardous waste and municipal solid waste incinerators, waste dumps and locations near petroleum and other industrial chemical plants. The results and potential health and environmental

impacts of these chemicals are presented below. These data in combination with existing data on PBDEs and lindane support IPEN’s contention that these chemicals have the same chemical characteristics as the dirty dozen initially listed in the Stockholm Convention, and should be added as targets for global elimination.



**Photo 1:** Petrochemical complex Pajaritos in Coatzacoalcos, Mexico and poultry - two subjects of this report.

## Recommendation:

The Persistent Organic Pollutants Review Committee (POPRC) should promptly add PBDEs and lindane (hexachlorocyclohexane, HCH) to the Stockholm Convention in order to eliminate their production and use around the world.

## Introduction

IPEN calls for the addition of polybrominated diphenyl ethers (PBDEs) and lindane (gamma-hexachlorocyclohexane, gamma-HCH) to the Stockholm Convention's list of POPs to be eliminated globally. To add to the growing body of evidence of the potential for severe human health and environmental impacts of these chemicals, IPEN coordinated the collection of chicken eggs from around the world and the determination of the concentrations in the eggs of the following chemicals: Brominated Flame Retardants: Polybrominated diphenyl ethers (PBDEs) and hexabromocyclododecane (HBCD); and Lindane and its major metabolite, beta-hexachlorocyclohexane, a useful indicator of lindane exposure.

The analytical results, in combination with existing data on PBDEs and lindane, support IPEN's contention that these chemicals exhibit many of the same characteristics as the "dirty dozen" persistent organic pollutants (POPs) initially listed in the Stockholm Convention, and should be included as targets for global elimination. We echo the recommendations of the European Commission to the Parties of the Convention on Long Range Transboundary Air Pollution on Persistent Organic Pollutants (LRTAP) and signatories of the Stockholm Convention in this regard (see Appendix I.)

Chicken eggs were collected in areas near an array of hot spots, including municipal solid waste, hazardous waste and medical waste incinerators. The PBDE concentrations in these eggs are compared to those in European wild bird eggs, in food in North America and Japan, and indoor dust in Europe and North America. These results add to and support other studies that collectively demonstrate that the levels of PBDEs in humans, wildlife and the environment are increasing rapidly, and that human exposures are ubiquitous, including in the air of homes and workplaces, and in

food. Similarly, concentrations of lindane in the eggs are compared to results of other studies as well as to recommended allowable concentrations in various countries.

### **Polybrominated Diphenyl Ethers (PBDEs)<sup>1</sup>**

PBDEs are a subclass of brominated flame retardants (BFRs.) Brominated and chlorinated flame retardants together make up approximately 25% of the world's market in chemical flame retardants<sup>2</sup>. BFRs are a growing business at over 200,000 metric tons globally in 2001<sup>3</sup>. The PBDEs used in manufacturing occur in three primary forms, penta, octa, and deca-BDE, with five, eight, and ten bromine atoms, respectively, around a common chemical core. Octa and deca-BDE are used primarily in plastics for electronics, while penta is found in the polyurethane foam of upholstered furniture. Two other BFRs, hexabromocyclododecane (HBCD) and tetra-bromo-bisphenol A (TBBPA) are increasingly used in electronics as well<sup>4</sup>. The Bromine Science and Environment Forum (BSEF), an association of bromine manufacturers, estimates that 90% of electronic appliances contain BFRs<sup>5</sup>.

PBDEs are of concern to human and animal health because of their effects on the developing brain, causing long-term neurological damage even at low levels of exposure<sup>6</sup>. Human health concerns center around the exponential increase in PBDE levels in human breast milk in both Europe and North America over the past two decades<sup>7</sup>. PBDEs are ubiquitous, they are found in rivers, sediment, sewage sludge, indoor and outdoor air, house dust, and a wide range of food products<sup>8</sup>. PBDEs have been found in fish, birds, and marine mammals, and show a strong tendency to bio-magnify up the food chain. Both in North American breast milk and in Scandinavian birds of prey, PBDE

concentrations reported in 2004 are reaching levels that have caused neurological damage in laboratory mice<sup>9</sup>.

All sources of PBDE exposure have not been identified. However, diet is regarded as the most likely route of exposure for the general population<sup>10</sup>. Recent studies have shown PBDEs and other chemicals present in house dust<sup>11</sup>. Air inside homes and offices can carry PBDE concentrations that are estimated to be almost ten times higher than levels in the air outside the buildings<sup>12</sup>. Moreover, house dust has been identified as an important pathway of PBDE exposure for young children<sup>13</sup>. Despite the ubiquity of PBDEs, information on their toxicology is limited<sup>14</sup>.

It is unclear whether the main exposure to humans and wildlife comes from BFR manufacture, or from the use and disposal of common consumer products.<sup>15</sup>

As a result of growing health concerns, some PBDEs have been banned or phased out in the European Union and in several states in the United States. The Intergovernmental Forum on Chemical Safety has stated that BFRs “should not be used where suitable replacements are available, and future efforts should encourage the development of further substitutes”<sup>16</sup>.

### **Lindane (Hexachlorocyclohexane)<sup>17</sup>**

Lindane, known technically by synonyms such as gamma benzene hexachloride and gamma-hexachlorocyclohexane (gamma-HCH), has been in use for about 50 years. Banned in at least 52 countries and severely restricted in more than 33 others, the organochlorine pesticide lindane is currently registered for use in Canada, Mexico and the U.S. While Mexico recently committed to phase out all uses and Canada has phased out all agricultural uses, the U.S. continues seed treatment uses of lindane for corn, wheat and a handful of other grains. In an

average year, 142,000 pounds of lindane are used agriculturally in the U.S. for seed treatment. Lindane use to control head lice and scabies also continues in the U.S. and Canada while individual states (California, Illinois) are phasing out its use.

Lindane is a neurotoxin<sup>18</sup>, a probable carcinogen<sup>19</sup>, and a suspected endocrine disruptor<sup>20</sup>. It affects the central nervous system and may cause headaches, dizziness, nausea, vomiting, mental confusion, seizures, coma and respiratory depression<sup>21</sup>. Children are significantly more susceptible to the toxic effects of lindane<sup>22</sup>. Lindane builds up in fatty tissues, and is found in human blood and breast milk worldwide<sup>23</sup>. Lindane is highly toxic to wildlife, including fish, bees, birds and mammals<sup>24</sup>.

Agricultural uses are largely responsible for the pervasiveness of lindane and its breakdown products in the Arctic environment, where it is found more often than any other pesticide. Indigenous peoples of the north who rely on traditional diets of marine mammals and fish are particularly at risk from lindane exposure through foods. In 1997, the Northern Contaminants Program estimated 15 to 20 percent of Inuit women on southern Baffin Island are exposed to dangerous levels of lindane in their daily diet<sup>25</sup>.

Safer alternatives are available for all lindane uses, including wet combing for head lice control<sup>26</sup> and crop rotation and other sustainable approaches to replace seed treatment<sup>27</sup>. Moreover, the effectiveness of lindane is decreasing; studies show that head lice are becoming resistant to lindane<sup>28</sup>.

Because of the restrictions on its use, lindane residues in food have been declining. The average daily intake (based on market-basket surveys) in the USA has dropped significantly between 1964-80 from 0.05 ug/Kg bw to 0.0028 ug/Kg bw, respectively<sup>29</sup>. However, the U.S. Centers for Disease Control and Prevention found that 25% of U.S. residents sampled in 2000

still carry beta-HCH (the primary metabolite and the marker of lindane exposure) in their blood at 19 ng/g of lipid weight, and the highest levels are found among women of childbearing age<sup>30</sup>. The half life of lindane in humans is less than a day, while the half-life of its major metabolite (beta-HCH) is 7

years. It is, therefore, more reliable to measure the latter.

**Photos 2 and 3:** Indian Pesticides Limited near Lucknow, Uttar Pradesh, India; factory manufacturing lindane and chlorpyrifos. In near village called Takia were sampled chicken eggs for analysis on HCH. There are obsolete stockpiles at pictures.



## Results and Discussion

### Brominated Flame Retardants

Figures 1 and 2 present the analytical results for PBDEs and HBCD in composite egg samples from eleven sampling locations across Europe, Asia, Africa, the Middle East, North and South America. Eggs were analyzed for eleven BDE congeners; data are plotted for BDE-47, BDE-99, BDE 153, BDE 183 and BDE-209, which were the congeners present at highest concentrations. The penta-BDE commercial mixture consists primarily of the BDE-47 and BDE-99 congeners. The

octa-BDE commercial mixture contains primarily the BDE-153 and BDE-183 congeners, while the deca-BDE commercial mixture is almost entirely BDE-209<sup>31</sup>.

The analytical protocol can be found in Appendix II. Descriptions of each of the sampling locations and results for PBDEs and lindane can be found in the tables below. Please note that more samples from different locations were obtained and measured for lindane, but several sampling locations overlap for both sets of analyses.

**Table 1: Sampling locations, concentrations of total PBDEs, HBCD, lindane and Beta HCH in composite egg samples, and characterization of sampling sites**

Sample Location	Σ PBDEs (ng/g fat)	HBCD (ng/g fat)	Lindane (ng/g fat)	Beta HCH (ng/g fat)	Characterization of sample site
Belarus - Bolshoi Trostenec	NA	NA	0.58	2.40	Dumpsite (fires)
Bulgaria - Kovachevo	NA	NA	1.10	19.50	Power plants, industrial area
Czech Republic - Liberec (fresh eggs)	2.0	< 3.0	2.00	0.60	Municipal waste incinerator, secondary steel production
Czech Republic - Liberec (boiled eggs)	0.8	< 3.0	2.30	0.43	Municipal waste incinerator, secondary steel production
Czech Republic - Lysá nad Labem	10.5	6.8	NA	NA	Hazardous waste incinerator
Czech Republic - Usti nad Labem	1.0	< 3.0	0.68	0.54	Chlorine chemical industry site, hazardous waste incinerator
Egypt - Helwan	NA	NA	0.66	52.50	Metallurgy, cement kilns
India - Eloor	NA	NA	3.00	85.40	Organochlorine pesticides production
India - Lucknow	NA	NA	18.90	390	Medical waste incinerator
India - Takia	NA	NA	23.40	3100	Organochlorine pesticides production

Kenya - Dandora	29.3	160.3	1.40	1.10	Dumpsite (fires)
Mexico - Coatzacoalcos	30.8	90.8	2.20	1.40	Petrochemical complex
Mozambique - Santos	12.3	18.9	1.30	4.50	Cement kiln burning waste
Pakistan - Peshawar	NA	NA	0.75	4.70	Mixed waste dumpsite
Philippines – Barangay Aguado	33.6	8.7	1.30	6.80	Medical waste incinerator
Russia - Gorbatovka	NA	NA	0.50	100.00	Chlorine chemical industry site, hazardous waste incinerator
Russia - Igumnovo	NA	NA	1.10	36.30	Chlorine chemical industry site, hazardous waste incinerator
Senegal - Mbeubeuss	NA	NA	2.00	4.00	Dumpsite (fires)
Senegal - Sangalkam	NA	NA	21.40	41.10	Pesticides application area
Slovakia - Kokshov-Baksha	29.3	89.2	0.48	1.80	Municipal waste incinerator
Tanzania - Vikuge	NA	NA	2.30	310	Obsolete pesticides storage
Turkey - Izmit	106.8	42.8	0.60	3.70	Hazardous waste incinerator
Uruguay - Minas	1.8	89.2	0.51	2.00	Cement kilns burning waste
USA - Mossville	23.4	7.2	1.70	0.27	PVC and oil industries

Chicken eggs were collected from sites near municipal solid waste, hazardous waste, and medical waste incinerators, as well as from locations near industrial chemical and petrochemical plants and one dumpsite. Concentrations of total PBDEs in the composite egg samples ranged from 0.8 to 106.8 ng/g lipid. For HBCD, concentrations

ranged from <3.0 to 90.8 ng/g lipid. Concentrations of individual PBDE congeners were as follows: BDE-47 (0.08 to 2.44 ng/g lipid), BDE-99 (0.13 to 4.56 ng/g lipid), BDE-153 (<0.05 to 1.94 ng/g lipid), BDE-183 (<0.15 to 8.97 ng/g lipid) and BDE-209 (0.8 to 106.8 ng/g lipid).

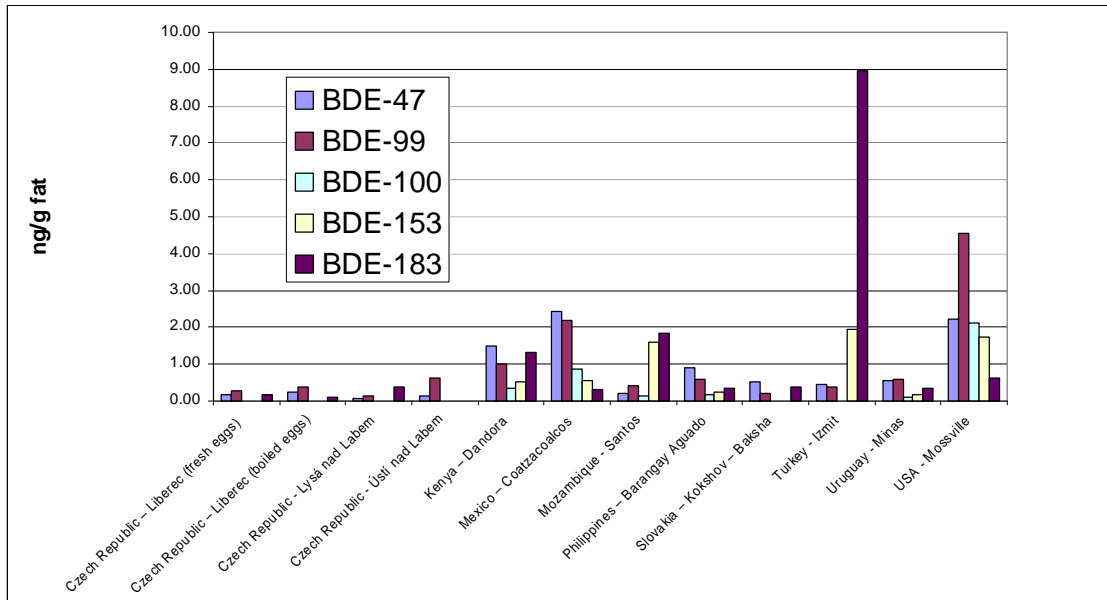


Figure 1: Concentrations of BDE-47, BDE-99, BDE-153, and BDE-183 in Composite Egg Samples (ng/g fat)

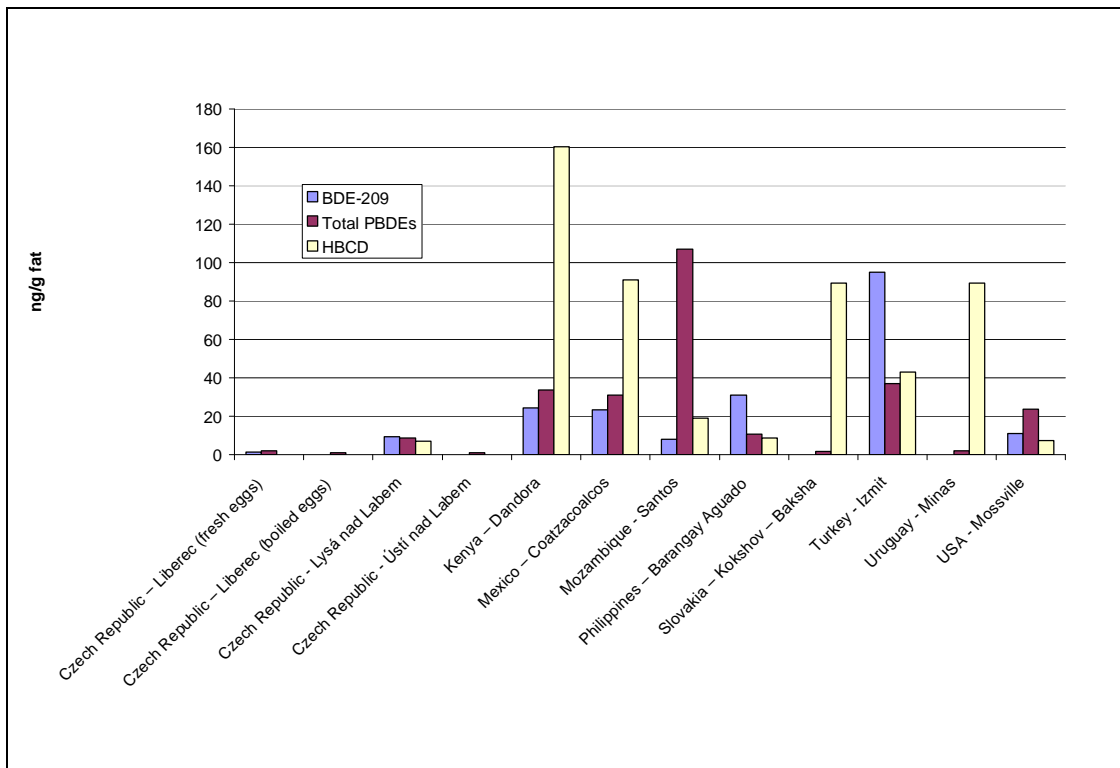


Figure 2: Concentrations of BDE-209, Total PBDEs and HBCD in Composite Egg Samples (ng/g fat)

As shown in Figures 1 and 2, composite egg samples from the two North American sampling locations had the highest concentrations of the lower PBDE congeners. The two African sites show concentrations of BDE-209 comparable to the North American results, but show lower levels of BDE-47, BDE-99, and BDE-153. Concentrations of PBDEs from the two European countries were relatively low, with the Philippines falling between values detected for Europe and Africa. Within the Czech Republic, samples from three different locations showed consistent levels of the lower BDE congeners. Levels of BDE 209 and HBCD were markedly higher in many locations than levels of the lower PBDE congeners, often by as much as an order of magnitude, particularly in the two North American locations. Turkey had a noticeably higher level of BDE 209 than any other sampling location. Only in Europe were the levels of BDE 209 similar to the levels of lower congeners in the same location.

The US location had remarkably high results for BDE 99, while the Turkey and Mozambique locations showed high results for BDE 153. HBCD levels were high in Mexico, Uruguay, and Slovakia, relatively high in Turkey, and extremely high in Kenya. There was no apparent correlation among levels of lower congeners and BDE 209 or HBCD levels. The two highest sets of sampling results were from an industrial location in Louisiana in the southern United States and from a waste dump in Nairobi, Kenya. It should be noted, however, that all samples contained some level of PBDEs and HBCD, including those that would not be located in areas of manufacturing of these chemicals, indicating an alternate mechanism of global distribution.

To our knowledge, these are the first sampling data on PBDEs in many of these countries, particularly in those of the developing world, particularly Africa, and in Asia outside Japan.

### **Summary of Related Data on PBDEs in Wild Bird Eggs, Food, and Indoor Dust**

Researchers currently believe that a combination of food, air, and dust may provide the main routes of human exposure to PBDEs<sup>32</sup>. The sampling data obtained by IPEN shows PBDEs and HBCD at concentrations higher than those found in studies of food to date, but comparable to data from the eggs of wild bird populations.

In 2004, researchers found that eggs from wild populations of Swedish peregrine falcons contained higher concentrations of PBDEs and HBCD than captive populations. The wild populations showed levels of 220-2700 ng/g lipid weight (lw) total PBDEs versus 39 ng/g lw in captive populations. The wild HBCD levels were 150 to 250 ng/g lw versus non-detect in the captive birds. The levels reported in Swedish falcons are the highest levels in wild birds to date, and the first record of BDE-183 and BDE-209 in high trophic-level wild life<sup>33</sup>.

A market basket study of fish, meat and dairy products from Texas supermarkets in 2004<sup>34</sup> identified median concentrations of 1725 pg/g wet weight (ww) PBDEs in fish, 283 pg/g ww in meat, and 31.5 pg/g ww in dairy products, with no detectable PBDEs in non-fat milk. The congeners detected in this study were BDE-47, BDE-99 and BDE-100, with the latter present only in fish, and BDE-47 dominating in fish and dairy products, but BDE-99 dominating in meat products.

A study of fish, meat, and vegetables from food markets in the city of Hirakata, Osaka prefecture, Japan, in 2001<sup>35</sup> identified total PBDE concentrations ranging from 21 to 1650 pg/g wet weight in fish and shellfish, 6.25 to 63.6 pg/g ww in meat (beef, pork and chicken) and 38.4 and 134 pg/g ww in vegetables sampled. Total PBDE concentrations in the breast milk of nursing mothers was in the range of 668 to 2840

pg/g lipid, with a strong positive correlation with dietary intake of fish and shellfish. These PBDE concentrations in human breast milk are comparable to levels found in nursing women in Sweden. Additionally, the researchers noted that PBDE concentrations in Japanese farmed mackerel were comparable to mackerel collected in northern European waters.

A Canadian study of food conducted in 2004<sup>36</sup> showed high levels of PBDEs in fish (3638 ppt, or pg/g in farmed rainbow trout and 1942 ppt in farmed Atlantic salmon), lower levels in meat (450 ppt in extra lean ground turkey, 242 ppt in sausages, 56 ppt in pork chops, and 32 ppt in medium ground beef and no detectable levels in chicken.)

A 2002 analysis of chicken fat from several sites in the United States<sup>37</sup> showed levels of PBDEs ranging from 1.7 to 39.4 ppb, with penta congeners predominating. This report placed their data at levels lower than those reported for Great Lakes and Baltic fish, but higher than those reported for terrestrial animals in Sweden. The highest chicken fat levels reported were comparable to levels found in Arctic seals and human adipose tissue.

Recent reports on dust found in USA homes and workplaces report results at the microgram/g or part per million (ppm) level. A Clean Production Action report released in February 2005<sup>38</sup> reports mean total PBDE concentrations in house dust at 12.5 ug/g (ppm.) with BDE-209 at the highest mean concentration of 4.66 ug/g, BDE-47 at 2.10 ppm, BDE-99 at 1.87ppm. BDE-100, -153, -154, and -183 present in lower concentrations.

Similarly, a 2004 study of dust and clothes dryer lint from homes in the Washington, D.C. area<sup>39</sup> found total PBDE concentrations at 78- to 30,100 ng/g dry mass in dust, dominated by congeners associated with the penta and deca commercial mixtures. Clothes dryer lint PBDE concentrations ranged from 480-3080 ng/g dry mass. The

results showed no correlation with year of house construction, type of flooring (e.g., carpet or other), or number of television sets or computers in the house.

An earlier study of indoor air and dust from homes on Cape Cod, Massachusetts<sup>40</sup>, in the United States showed levels of tetra (BDE-47) and penta (BDE-99) BDE at 0.7 to 4.1 ug/g dust. A study of brominated flame retardants in dust on computers<sup>41</sup> found octa-BDE at 0.553 to 58 pg/cm<sup>2</sup>, nona-BDE at 1.19-85.2 pg/cm<sup>2</sup>, and deca-BDE at 11.3 to 213 pg/cm<sup>2</sup>. A 2003 Greenpeace study of homes in the UK and continental Europe<sup>42</sup> found the deca congener to be the most abundant in house dust at 3.8 to 19.9 ppm. Penta was also present at 0.0018 to 2.1 ppm.

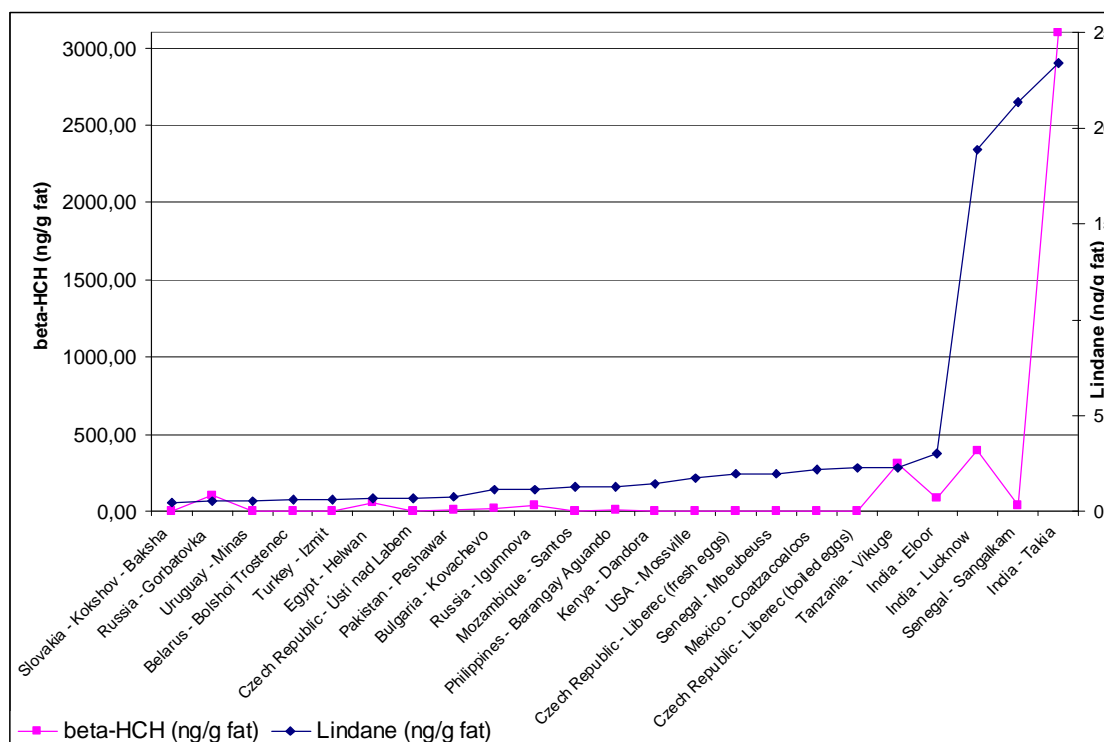
Many of the studies of food and dust described above were conducted in response to earlier studies that found high levels of PBDEs in human breast milk. Of even greater concern is that levels of PBDEs currently identified in human breast milk and wildlife are approaching levels that produce developmental and neurological impacts in laboratory animals<sup>43</sup>.

## **Lindane<sup>44</sup>**

Because of its longer half life, beta-HCH is a good biomarker for exposure to lindane. Summary statistics of the analytical results (on a lipid basis) for both lindane and beta-HCH are shown on Table 1. Figure 3 depicts lindane and beta-HCH concentrations in all samples in an ascending order. Lindane was measured above the detection limit (0.1 or 0.2 ng/g fat) in all 30 samples, while beta-HCH was detected in all samples. Lindane concentrations ranged from 0.2 ng/g fat to 23.4 ng/g fat with a mean of 3.2 ng/g fat. Concentrations of beta-HCH ranged from less than 0.2 ng/g fat to 3,100 ng/g fat with a mean of 575 ng/g fat. Distributions were skewed. The three samples with the highest lindane concentrations (India OCP factory, Senegal Sangalcan, India Lucknow) were statistical outliers<sup>45</sup>, while the beta-HCH samples were comprised of two sub-

populations, i.e., 19 samples below approximately 20 ng/g fat and 10 samples above 20 ng/g fat. All three samples from India ranked among among the five highest in lindane. The sample highest in both lindane and beta-HCH was the sample of eggs in the vicinity of an OCP factory. No geographical pattern was evident across

countries or continents. In short, a very wide range of concentrations was measured for both chemicals. Whereas the three samples highest in lindane had also high levels of beta-HCH, many samples with intermediate lindane concentrations had high concentrations of beta-HCH, reflecting the relative half-lives of the two chemicals.



**Figure 3: Concentrations of Beta-HCH and Lindane in Composite Egg Samples (ng/g fat)**

There are extremely limited data on lindane in chicken eggs. In 2000, a Japanese study reported levels below 1 ng/g fat for both lindane and beta-HCH in eggs<sup>46</sup>. Higher levels have been reported in the 1970s, while lindane was still in use<sup>47</sup>.

No limit for lindane residues in eggs is posted by the United States Department of Agriculture (USDA.) The Food and Agricultural Organization (FAO) has set an

allowable limit for lindane in eggs at 0.01 mg/kg<sup>48</sup>. Assuming an average lipid content of 12% (as observed with this study), the allowable limit on a fat basis would be 83 ng/g fat. All samples in this survey were below this limit. Obviously, other sources of lindane contribute to a person's intake, and children and other subpopulations are known to be more vulnerable to lindane exposure.

## Appendix I: Recommendations by Other Bodies<sup>49</sup>

The United Nations Economic Commission for Europe (UNECE) in 1979 negotiated the Convention on Long Range Transboundary Air Pollution on Persistent Organic Pollutants (LRTAP). A 1998 Protocol to LRTAP listed 16 substances that are subject to production and use prohibitions or restrictions or emission control measures. Of these 16 substances, 12 are also covered by the Stockholm Convention for Persistent Organic Pollutants. The other four substances covered under the LRTAP Protocol are:

- Chlordecone
- Hexabromobiphenyl
- Hexachlorocyclohexane (HCH, including lindane)
- Polycyclic aromatic hydrocarbons (PAH)

In August 2004, the European Commission, on behalf of the countries that are party to the Protocol to the 1979 Convention on Long Range Transboundary Air Pollution on Persistent Organic Pollutants (LRTAP) proposed the addition of seven substances or

classes of substances to the Protocol. These substances are:

- Hexachlorobutadiene
- Octabromodiphenyl ether (octaBDE)
- Pentabromodiphenyl ether (pentaBDE)
- Pentachlorobenzene
- Polychlorinated naphthalenes
- Short-chained chlorinated paraffins

The Commission proposes that the following substances be added to the Stockholm Convention on Persistent Organic Pollutants:

- Hexachlorobutadiene
- Octabromodiphenyl ether (octaBDE)
- Pentabromodiphenyl ether (pentaBDE)
- Pentachlorobenzene
- Chlordecone
  - Hexabromobiphenyl
  - Hexachlorocyclohexane (HCH, including lindane)
- Polychlorinated naphthalenes
- Short-chained chlorinated paraffins

**Photo 4:** Egg sampling in Barangay Aguado, Philippines.



## **Appendix II: Sampling and Analytical Methodology**

Eggs were collected from selected sites, usually near known sources of contamination. Eggs were boiled prior to shipping to the laboratory to allow shipment at ambient temperatures. Upon arrival, the samples were kept frozen until analysis. Because of boiling, concentrations measured in the eggs reflect concentrations at which individuals consuming those eggs would be exposed to. It is possible that these concentrations are different, probably lower, than the concentrations in the raw eggs reflecting exposures to foraging animals, because many of the contaminants measured degrade at high temperatures.

The analysis of PBDEs in eggs was performed by the Institute of Chemical Technology, Department of Food Chemistry and Analysis, Technicka 5, 166 28 Prague 6, Czech Republic. Analysis for lindane and other organochlorine pesticides was performed by Axys Varilab in the Czech Republic.

### **Analytical methods:**

#### **PBDEs**

Composite samples of eggs were prepared by homogenization of whole boiled eggs (white egg and yolk) in mincing machine. The isolation of target compounds from egg samples was performed by Soxhlet extraction with n-hexane and

dichloromethane as extraction solvent mixture. The clean-up of crude extracts was carried out by gel permeation chromatography (GPC). Identification of flame retardants (BFRs) - polybrominated diphenyl ethers (PBDEs) and hexabromocyclododecane (HBCD) was carried out by high resolution gas chromatography connected to mass spectrometric detector with quadrupole analyser operated in negative chemical ionisation mode (HRGC-MSD-NCI). The monitored ions (m/z) were 79, 81, 159 and 161. Ion at m/z 79 was used for quantification. For BDE 209 separation was carried out on DB-XLB (15m x 0.25 mm x 0.1 um) capillary column, with pressure pulse. Selective ion m/z in addition to ions 79 and 81 were used for detection, we also used selective m/z 486.7 (487

#### **Lindane**

The egg shells were removed and edible contents of 3 - 6 eggs was homogenised. A 30 g subsample was dried via sodium sulphate, spiked with internal standards and Soxhlet extracted with toluene. An aliquot was used for gravimetric lipid determination. The extract was cleaned up with acidified silica gel and further purified and fractionated on a carbon column. The fraction containing the organochlorine pesticides was analysed by HRGC/MS (Autospec Ultima NT).

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