

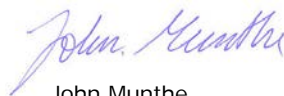
# Screening of Emerging Brominated Flame Retardants (BFRs) and Polybrominated dibenzofurans (PBDFs)

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## **Summary**

As an assignment from the Swedish Environmental Protection Agency, a screening study of selected emerging brominated flame retardants (BFRs) and polybrominated dibenzofurans (PBDFs) has been carried out. Additional substances in the screening were polybrominated diphenyl ethers (PBDEs), polybrominated dibenzodioxins (PBDDs) and chlorinated dioxins and furans (PCDDs and PCDFs).

The overall objective of this screening study was to determine the concentrations of selected BFRs and PBDFs in a variety of media in the Swedish environment. Additional aims were to assess possible emission sources and to highlight important transport pathways in the environment including large scale transport. An issue for the screening was also to investigate the presences of the BFRs in biota to give an indication if they pose an environmental risk. Possible human exposure was investigated by analysing BFRs in human blood samples and PBDFs in human milk samples.

Measurements have been carried out both at background- and urban sites. The sampling was mainly performed at the Swedish west coast with Göteborg representing the urban area. Sediment and biota was sampled in the estuary of Göta Älv and in a background area.

For identification of pathways to the environment storm water/sludge and samples from WWTPs were collected. Dust samples from different indoor environments were taken both at public spaces and in homes. Air and dust samples were collected at a recycling industry for electronic waste. Fire extinguishing water from a fire at a recycling industry was included in the sampling program.

The emerging BFRs, PBDEs and PBDFs occurred in “high” concentrations in air and dust from the recycling industry. The occurrence of BFRs at this electronic waste facility shows that electronic articles contain these chemicals. BDE-209 and DBDPE were found in highest concentrations. DBDPE has similar applications as BDE-209 and it has been marketed as a general substitute for this chemical. The occurrence of PBDFs may indicate that the BFRs are contaminated or that PBDEs are transformed to PBDFs in the recycling processes.

The presence of both the emerging BFRs and PBDEs in dust collected in a “new private car” shows that these flame retardants are used in textiles and plastic details in newly manufactured cars. DBDPE and BDE-209 which are used as flame retardants in textiles occurred in high concentration. The simultaneous occurrence of high levels of PBDFs indicates presence in BFR formulations.

The occurrences of the included BFRs in dust from different indoor environments indicates a wide application of these chemicals in articles and household products and that diffuse emissions of BFRs from consumer products may take place in the indoor environment. The differences in the distribution among the BFRs for the different dust samples indicate that the BFRs may originate from different consumer product and articles.

Higher ratios of PBDFs vs. BDE-209 were found in dust from environments that are likely to contain BFR containing plastics (offices and recycling facilities) than in dust from environments containing BFR treated textile products (car and conference center interiors). This may indicate that PBDFs are formed during production or use of flame retarded plastics.

The emissions of BFRs and PBDFs will take place both to air and water. BFRs and PBDFs emitted indoors to air and to settled dust may via ventilation be transported to outdoor air. The presence of these pollutants in influent, effluent and sludge from municipal WWTPs also indicate that diffusive emissions from household products occur and that these chemicals may be emitted to the environment from WWTPs. The occurrence of the BFRs and PBDD/Fs in storm water and fire extinguishing water shows that this may also be pathways to the environment.

Thus, the emerging BFRs and PBDFs were generally found in samples from WWTPs, storm water, indoor air and dust, indicating that they may be emitted and transported to the environment via these sources and pathways.

Several of the emerging BFRs occurred in all the included environmental matrices except in atmospheric deposition. The concentrations in samples at urban sites were higher compared to background samples.

Most of the emerging BFRs were detected in urban air, in the same levels or somewhat lower than BDE-47, -100 and -99. BDE-209 occurred in the highest concentrations. One of the emerging BFRs, HBB, was detected in background air, in the same concentration range as the PBDEs. It was found both at the Swedish West coast and in the remote area in Northern Finland, which shows the potential for atmospheric long range transport for HBB.

PBDD/Fs were found in all air and deposition samples. There appears to be an annual variation in both PBDD/F and PCDD/F concentrations, with higher levels during winter. Significantly elevated levels were detected in May-June 2011, which coincided with extensive forest fires in southern Russia and Ukraine.

In sediments, the emerging BFRs were only detected in a sample from Göta Älv near a former industrial site where they occurred in the same concentration level as the penta-BDEs.

The occurrence of emerging BFRs in biota from background sites shows that these chemicals like the PBDEs are further spread to the ecosystem. The distribution of the BFRs differed between the various species as well as among the different sampling sites.

The only emerging BFR detected in human sera was PBEB, which occurred in one out of 15 samples. PCDD/Fs were found in all human milk samples, but no PBDD/Fs were detected.

## Sammanfattning

På uppdrag av Naturvårdsverket har en screeningstudie av utvalda "nya" bromerade flamskyddsmedel (BFRs) och polybromerade dibensofuraner (PBDFs) genomförts. Ytterligare substansgrupper var polybromerade difenyletrar (PBDEs), polybromerade dibensodioxiner (PBDDs) och klorerade dioxiner och furaner (PCDDs och PCDFs).

Undersökningens ändamål var att bestämma koncentrationer av vissa BFRs och PBDFs i ett antal olika medier i den svenska miljön och dessutom bedöma möjliga källor och spridningsvägar i miljön inklusive storskalig transport. En uppgift var också att undersöka förekomst av BFRs i biota och indikera om detta kan utgöra en miljörisk. Möjlig human exponering belystes genom analys av BFRs i humana blodprov och av PBDFs i modersmjölk.

Mätningar har gjorts både i bakgrundslokaler och i urbant påverkade områden. Provtagning gjordes huvudsakligen på svenska västkusten, med Göteborg som urbant område. Sediment och biota provtogs i Göta älvs mynningsområde och vid en bakgrundslokal.

För att identifiera spridningsvägar till miljön provtogs dagvatten/dagvattenslam och vatten och slam från avloppsreningsverk. Damm från olika inomhusmiljöer provtogs både i offentliga lokaler och i hemmiljö. Luft och damm provtogs i en återvinningsindustri. Brandsläckningsvatten från en brand i en återvinningsindustri ingick också.

"Nya" BFRs, PBDEs och PBDFs förekom i "höga" koncentrationer i luft och damm från återvinningsindustrin. Förekomsten av BFRs här visar att elektriska artiklar innehåller dessa kemikalier. BDE-209 och DBDPE förekom i högst koncentrationer. DPDBE har likartat användningsområde som BDE-209 och har marknadsförts som en ersättningskemikalie för denna. Förekomsten av PBDFs kan indikera att BFRs är kontaminerade eller att PBDEs transformeras till PBDFs i återvinningsprocessen.

Förekomsten av både de "nya" BFRs och PBDEs i damm som provtogs i en ny personbil, visar att dessa flamskyddsmedel används i textilier och plastdetaljer i nytillverkade bilar. DBDPE och BDE-209, som används som flamskyddsmedel i textilier, förekom i höga koncentrationer.

Förekomsten av de i studien ingående bromerade flamskyddsmedlen i damm från olika inomhusmiljöer visar en bred användning av dessa kemikalier i varor och hushållsprodukter och att diffusa utsläpp från konsumentprodukter kan ske i inomhusmiljön. Skillnaderna i fördelningen mellan ämnena i olika dammprover indikerar att BFR kan härröra från olika varor och konsumentprodukter.

En högre andel PBDFs jämfört med BDE-209 förekom i damm från miljöer som sannolikt innehåller BFR-plast (kontor och återvinningsanläggningar) än i damm från miljöer där BFR behandlade textilprodukter används (bil och konferenscenterinteriörer). Detta kan tyda på att PBDFs bildas under produktion eller användning av flamskyddade plaster.

Utsläppen av bromerade flamskyddsmedel och PBDFs sker både till luft och vatten. BFRs och PBDFs som avges inomhus till luft och damm, kan via ventilationen transporteras vidare till utomhusluften. Förekomst av dessa föroreningar i inkommande och utgående vatten samt slam från kommunala reningsverk tyder också på att diffusa utsläpp från hushållsprodukter förekommer och att dessa kemikalier kan spridas till miljön från avloppsreningsverk. Förekomsten av bromerade flamskyddsmedel och PBDD/Fs i dagvatten och släckvatten från bränder visar att dessa också kan utgöra spridningsvägar till miljön.

Således, ”nya” BFRs och PBDFs förekom generellt i prover från reningsverk, dagvatten, inomhusluft och damm, vilket indikerar att de kan släppas ut och transporteras till miljön via dessa källor och spridningsvägar.

Flera av de ”nya” BFRs förekom i alla ingående miljömatiser utom i atmosfäriskt nedfall. Koncentrationerna i proven i urbana platser var högre jämfört med bakgrundsprover.

De flesta av ”nya” BFRs förekom i urban luft, i samma nivåer eller något lägre än BDE-47, -100 och -99. BDE-209 förekom i de högsta koncentrationerna. En av den nya BFRs, HBB, detekterades i bakgrundsluft i samma koncentrationer som PBDE. Förekomsten av HBB både på den svenska västkusten och i norra Finland, visar på en potentiell långväga atmosfärisk transport av HBB.

PBDD/Fs förekom i alla luft-och depositionsprover. Det verkar förekomma en årlig variation i både PBDD/ Fs och PCDD/ Fs koncentrationer, med högre nivåer under vintern. Signifikant förhöjda nivåer detekterades i maj-juni 2011, vilket sammanföll med omfattande skogsbränder i södra Ryssland och Ukraina.

I sediment påvisades ”nya” BFRs endast i ett prov från Göta älv, i närheten av ett tidigare industriområde där halterna var i samma storleksordning som för penta-BDE.

Förekomsten av nya bromerade flamskyddsmedel i biota från bakgrundsområden, visar att dessa kemikalier, precis som PBDE, sprids till ekosystemet. Fördelningen av BFRs skilde sig mellan de olika arterna samt mellan de olika provtagningsplatserna.

Den enda av de ”nya” BFRs som detekterades i humant serum var PBEB, som förekom endast i ett av totalt 15 prover. PCDD/Fs detekterades i alla modersmjölkprover, däremot kunde PBDD/Fs inte påvisas i några av prover.

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## 1 Introduction

As an assignment from the Swedish Environmental Protection Agency, a screening study of selected emerging brominated flame retardants (BFRs) and polybrominated dibenzofurans (PBDFs) has been carried out. Additional substances in the screening were polybrominated diphenyl ethers (PBDEs), polybrominated dibenzodioxins (PBDDs) and chlorinated dioxins and furans (PCDDs and PCDFs).

The overall objective of this screening study was to determine the concentrations of selected BFRs and PBDFs in a variety of media in the Swedish environment. Additional aims were to assess possible emission sources and to highlight important transport pathways in the environment including large scale transport. An issue for the screening was also to investigate the presences of the substances in biota to give an indication if they pose an environmental risk. Possible human exposure was investigated by analysing BFRs in human blood samples and PBDFs in human milk samples.

## 2 Background: Substances in the screening, properties, sources

### 2.1 Brominated flame retardants (BFRs)

Brominated flame retardants (BFRs) are used to reduce the flammability in many products, including furniture, building materials and electronics. BFRs are expected to be emitted to the environment during the use-phase of goods and products. Furthermore, the substances may be emitted during industrial processes or be produced unintentionally and be emitted from combustion processes.

Polybrominated diphenyl ethers (PBDEs) have previously been used in high volumes but due to their ubiquitous environmental presence and potential toxicities pentaBDE and octaBDE have been banned in EU (EG 850/2004). All PBDEs have been banned in electrical equipment in EUs, RoHS directive. The phase out of PBDEs has led to an increasing number of alternative flame retardant chemicals which have been introduced to comply with consumer product fire safety standards.




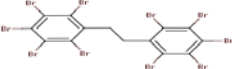
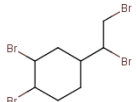
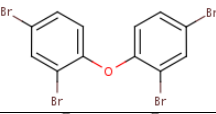
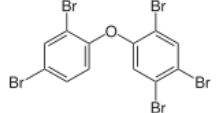
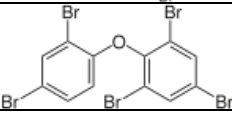
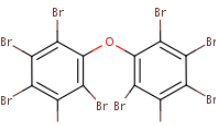
Recently the occurrence of “new” brominated flame retardants (BFRs) in environmental samples from the Nordic countries has been investigated (Schlabach *et al.*, 2011). The overall results of this Nordic screening showed that emerging brominated flame retardants were regularly found in many different sample matrices indicating a widespread use of these substances in the Nordic countries but there were geographical differences and differences in the environmental occurrence among substances and groups of substances. However the measurements were carried out in several media at several sites and with only a few samples from each site which gives a “snap shot” of the situation. Therefore, follow up studies for identification of emission sources and important pathways as well as



investigations of the ecotoxicology and human effects were recommendations based on the results from the Nordic screening.

All BFRs selected for this screening were frequently found in biota in the previous Nordic screening. In addition selected PBDEs were included as reference substances. The substances included in the screening are presented in Table 1 with abbreviations, CAS-number and structure. The novel abbreviations recommend by Bergman *et al.*, 2012 are also included.

**Table 1.** Substances selected for the study (Name, CAS #, practical and structural abbreviation (EFSA 2012), structure).

Compound name CAS # Practical abbreviation Structured abbreviation	Structure
Hexabromobenzene CAS 87-82-1 HBB HxBBz	
Pentabromotoluene CAS 87-83-2 PBT PeBT	
Pentabromoethylbenzene CAS 85-22-3 PBEB PeBEtBz	
Decabromodiphenyl ethane CAS 84852-53-9 DBDPE DBDPEiPhEt	
1,2-Dibromo-4-(1,2-dibromoethyl)cyclohexane CAS 3322-93-8 TBECH (BDE-DBCH)* DiBEt-DiBcH	
2,2',4,4'-Tetrabromodiphenyl ether CAS 5436-43-1 BDE-47	
2,2',4,4',5-Pentabromodiphenyl ether CAS 32534-81-9 BDE-99	
2,2',4,4',6- Pentabromodiphenyl ether CAS 189084-64-8 BDE-100	
Decabromobiphenyl ether CAS 1163-19-5 BDE-209 (decaBDE)	

\*The abbreviation BDE-DBCH is suggested by Bergman et al 2012; however TBECH is used in this report

## 2.1.1 Properties, pathways and occurrence

Basic physical and chemical properties are given in **Table 2**.

**Table 2.** Properties of the BFRs included in the screening

Compound	Vapour pressure (Torr)	Water solubility (µg/L)	Log K <sub>ow</sub>	Ref.
HBB	$8.5 \times 10^{-7}$	0.16	6.11	EFSA, 2012 (Vp, logKow) ChemIDPlus (Water sol.)
PBT	$4.5 \times 10^{-6}$	0.94	6.25	
PBEB	$1.2 \times 10^{-6}$		6.76	
DBDPE	$6.0 \times 10^{-15}$	0.00021	11.1	
TBECH	$2.2 \times 10^{-5}$	69	4.82	
BDE-47	$1.9 \times 10^{-6}$	11	6.81	EPA (1)
BDE-99	$3.8 \times 10^{-7}$	2.4	6.5-8.4	EPA (2)
BDE-209	$3.5 \times 10^{-8}$	<0.1	6.3-12.6	EPA (3)

EPA (1) <http://www.epa.gov/iris/toxreviews/1010tr.pdf>

EPA (2) <http://www.epa.gov/iris/toxreviews/1008tr.pdf>

EPA (3) <http://www.epa.gov/iris/toxreviews/0035tr.pdf>

In a report by Harju *et al.* (2008) and in EFSA (2012) emerging BFRs have been reviewed thoroughly.

Hexabromobenzene (HBB), pentabromotoluene (PBT) and pentabromoethylbenzene (PBEB) have similar chemical structure and properties such as vapour pressure (Vp), water solubility and log Kow (Table 2). The low water solubility and high log Kow of HBB, PBT and PBEB predicts that they in the aquatic environment will be attached to and transported by particles to the sediment. In waste water treatment plants (WWTPs) they are expected to be found in the sludge. The reference substances BDE-47, BDE-99 have somewhat lower Vp and higher log Kow compared to HBB, PBT and PBEB.

HBB is a fully aromatic perbrominated substance. It may undergo nucleophilic aromatic substitution with strong nucleophiles and reductive debromination under environmental conditions. PBT is a stable aromatic substance that may undergo reductive debromination in the environment. It may also be an environmental transformation product of tetrabromobisphenol A (TBBPA) and other BFRs, such as decabromodiphenylethane (DBDPE) (Møskeland, 2010). PBEB is regarded as a substance showing high persistence in the environment, although it may undergo reductive and photolytic debromination. In the OSPAR list of chemicals it is ranked as persistent, liable to be bioaccumulative and toxic (OSPAR, 2011).

HBB, PBT and PBEB have frequently been found in different environmental matrices such as air, water, sediment, aquatic biota and wildlife as well as in indoor air, dust and in samples from waste water treatment plants (WWTPs) (Schlabach *et al.*, 2011, EFSA, 2012). The highest ambient air concentrations occur close to source areas (urban areas) but these chemicals are also found in background air. Their occurrence at remote sites in the Arctic shows that they are stable enough to be transported over long distances and that the atmosphere can act as an important environmental pathway. Their occurrence in biota and

in wildlife from background areas also indicates that these substances may have a bioaccumulation potential. HBB has also been detected in human samples (milk and blood serum).

Decabromodiphenyl ethane (DBDPE) has experimentally been shown to undergo debromination and thermal transformations (Kierkegaard *et al.*, 2009). This substance is like HBB, PBT and PBEB frequently found in several environmental media as well as in indoor air, dust and sludge samples. The occurrence in Swedish background air indicates that it will undergo atmospheric long range transport. DBDPE like BDE-209 exists in the atmosphere almost exclusively in the particles phase and the atmospheric transport is determined by the transport behaviour of the particle they are attached to.

1,2-Dibromo-4-(1,2-dibromoethyl)cyclohexane (TBECH) can exist as four pairs of enantiomers. Technical TBECH has a near 1:1 relationship between the  $\alpha$ - and  $\beta$ -diastereomers (Tomy *et al.*, 2008). At temperatures above 120 °C, some thermal conversion of the  $\alpha$ - and the  $\beta$ - isomers can occur, resulting in formation of  $\gamma$ - and  $\delta$ -isomers. TBECH has been detected in different biota samples and it was also found in air in the Nordic screening study (Schlabach *et al.*, 2011).

## 2.1.2 Production and use

HBB, PBT, PBEB, DBDPE and TBECH are all used as additive flame retardants. PBT, PBEB and DBDPE are listed as LPV chemicals in the European Chemical Substances Information System (ESIS, 2012). (LPV: 10 - 1000 tonnes produced or imported annually).

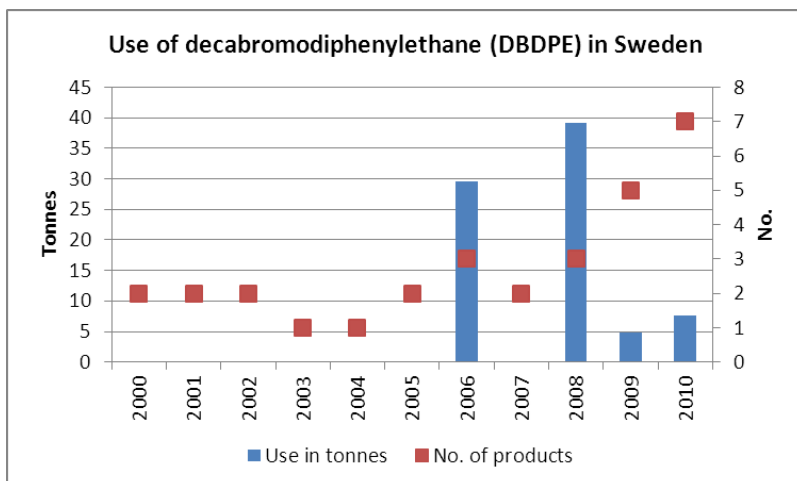
HBB and PBT have generally been used as flame retardants in e.g. polymers, plastics, textiles, wood, and paper as well as in electronic devices (Xie *et al.*, 2011). The use of HBB in Japan between 1994 and 2001 has been reported to be 350 tons per. HBB is not reported to be produced in Europe (EFSA, 2012). PBT is mainly used in unsaturated polyesters (OECD, 1995), polyethylene, polypropylene, polystyrene, SBR-latex, textile, rubbers and ABS with a global production volume estimated to between 1 000 and 5 000 tonnes annually.

PBEB has been reported to be used as an additive flame retardant in unsaturated polyesters, styrene butadiene copolymers and in other textiles but also in circuit boards, adhesives, wire and cable coatings and polyurethane foam (WHO/ICPS, 1997; Hoh *et al.*, 2005).

There is no information about the Swedish usage of HBB, PBT, and PBEB in chemical products (KemI-Stat, 2012).

DBDPE is an additive flame retardant which was introduced more than twenty years ago and that has similar applications as decaBDE and it has been marketed as general purpose substitute for decaBDE. It is used in applications such as plastics (including polyester and vinyl ester resins, rubber products and in different applications related to manufacture of textiles and leather. The compound is also used in polymers used for electronic and

electrical applications. DBDPE could also be used in adhesives and sealants. The use of DBDPE in chemical products in Sweden according to the Swedish Chemical product register was during 2006 and 2008-2010 between 5 and 40 tonnes annually (KemI-stat, 2012) (Figure 1). The information for other years is confidential. The number of chemical preparations has increased in recent years (Figure 1).



**Figure 1.** Use of decabromodiphenylethane (DBDPE) in number of chemical preparations and in tonnes (KemI-stat, 2012). Information on usage 2000-2005 and 2007 in Sweden is confidential.

TBECH (DBE-DBCH) is marketed as Saytex BCL-462. This material is primarily used as an additive flame retardant in expandable polystyrene beads, which are largely used to produce thermal insulation for housing. Concentrations of TBECH in these products are about 1% (Tomy *et al.*, 2008). TBECH is also used in polystyrene foam, in adhesive in fabric and vinyl lamination, electric cable coatings etc. There is no information about the use of TBECH in chemical products in Sweden (KemI-Stat, 2012).

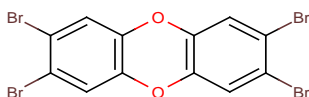
## 2.2 Polybrominated dibenzodioxins (PBDD) and -furans (PBDF)

### 2.2.1 Properties, pathways and formation

Brominated dioxins (PBDDs) and dibenzofurans (PBDFs) have similar properties and distribution pattern as their chlorinated counterparts. The higher molecular weight of bromine compared to chlorine makes PBDDs and PBDFs more lipophilic and non-volatile compared to the corresponding chlorinated substances. The stability in soil, sediment and biota is similar to that of chlorinated dioxins, but the brominated substances may undergo photochemical reactions more easily in water and air, which may lead to the formation of more stable brominated dioxins. The atmosphere is an important transport medium because the emissions take place here and atmospheric deposition is a major pathway to aquatic and terrestrial ecosystems. Soil and sediment are the major sinks where these substances can be very persistent.

PBDDs and PBDFs have similar toxicological properties as the chlorinated dioxins and furans. Congeners substituted with both chlorine and bromine has shown a relative potency even higher than for TCDD (Birnbaum *et al.*, 2003).

PBDDs and PBDFs and bromochlorodioxins are like chlorinated dioxins primarily formed by combustion processes or in other high temperature processes. The structure of one congener is shown in Figure 2 and the target compounds are listed in Table 3.



**Figure 2.** Structural formula of 2,3,7,8-tetrabromodibenzofuran.

**Table 3.** Target compounds and compound classes

Congeners	Totals
2378-TBDF	TBDF-tot
12378-PeBDF	PeBDF-tot
23478-PeBDF	HxBDF-tot
123478-HxBDF	HpBDF-tot
1234678-HpBDF	OctaBDF
OctaBDF	Σ PBDF
2378-TBDD	TBDD-tot
12378-PeBDD	PeBDD-tot
123478+123678-HxBDD	HxBDD-tot
123789-HxBDD	HpBDD-tot
1234678-HpBDD	OctaBDD
OctaBDD	Σ PBDD

The formation of both brominated and chlorinated dioxins may take place if the fuel contains high levels of chlorine and/or bromine. Main sources of formation of PBDDs and PBDFs are combustion plants with electronic waste and other waste containing flame retardants, and at industries dealing with brominated flame retardants as well as products containing those.

In the environment these substances can be formed by photochemical transformation of PBDEs and hydroxyl-PBDE or through enzymatic coupling of bromophenols and hydroxyl-PBDEs (Haglund, 2007, Arnoldsson *et al.*, 2012a, Arnoldsson *et al.*, 2012b).

## 3 Sampling program

### 3.1 Sampling strategy

A sampling strategy was developed to determine concentrations of the selected BFRs and PBDFs in different matrices in the Swedish environment. The sampling program was also aimed to identify possible emission sources and important environmental transport pathways. An issue for this screening was to investigate the presence of these substances in biota to get an indication if they pose an environmental risk and to identify possible human exposure. Measurements were carried out both at background- and urban sites. The sampling was mainly performed at the Swedish west coast with Göteborg representing the urban area.

The measurements in background areas were undertaken to get background concentrations (reference values) but also to identify the importance of atmospheric long range transport and deposition of the BFRs and PBDFs. In order to identify source areas for PBDFs additional short-time air samples were taken. The origin of the air masses were evaluated by trajectory studies (see below).

In order to investigate the occurrence of the selected BFRs in an urban area, the sampling program included different environmental media, such as outdoor air, deposition, sediment and biota. For identification of pathways; atmospheric deposition, storm water, effluents and sludge from waste water treatment plants (WWTPs) were sampled.

To identify the importance of diffuse emissions of BFRs from consumer products, dust samples from indoor environments were collected.

In order to investigate emissions of BFRs from potential point sources measurements were carried out during recycling of electronic waste including plastic material. Samples were also collected during unintentional fires at a recycling facility for electronic waste.

Possible human exposure was investigated by analysing human blood samples (serum) for BFRs and human milk for PBDFs.

#### 3.1.1 Sampling sites and sampling program

The air and deposition measurements were carried out at two background sites, Råö, an EMEP (Co-operative programme for monitoring and evaluation of the long-range transmission of air pollutants in Europe) station at the Swedish west coast, and Pallas, a remote station in northern Finland within AMAP (Arctic Monitoring Assessment Programme). The measurements at Råö and Pallas were co-ordinated with the Swedish Monitoring Programme for Air Pollutants. The air and deposition sampling were carried out in parallel and undertaken to investigate possible seasonal variation. At Råö short-time

air sampling (2-3 days) was performed during the summer and winter 2011. Totally, 20 samples were collected out of which ten were analysed for PBDFs.

The air samples from Göteborg were collected in urban background (roof level), close to high-traffic streets.

Sediment was sampled in the estuary of Göta Älv and a background sample was collected at Väderöarna at the Swedish west coast. Biota samples were taken at background locations along the Swedish west coast (fish) and in urban area Göteborg (molluscs).

Storm water was taken at three sites in the centre of Göteborg. Both water and storm water sludge was included. The storm water sludge were only analysed for PBDFs.

Influent, effluent and sludge were collected at Ryaverket WWTP (Göteborg) and at Gässlösa WWTP (Borås, approximately 60 km east of Göteborg).

Dust samples from indoor environments were taken both at public spaces such as a school, an office and conference centre and in a private home (office and bedroom). Dust from a new private car was also included. More sampling details are given in Appendix 1.

Air (gas and particles) and dust samples were collected at a recycling industry. More sampling details are given in Appendix 1. Further, two plastic material samples from a recycling industry were included, a plastic fraction containing BFRs and a fraction containing ABS (Acrylonitrile Butadiene Styrene), HIPS (High Impact Polystyrene) and PP (Polypropene).

Fire extinguishing water from a fire at a recycling industry was included in the sampling program.

The sampling programme for BFRs is shown in **Table 4** and for PBDFs in **Table 5**. Detailed information about individual samples is given in the Appendix 2.

**Table 4.** Sampling programme for BFRs, number of samples at the different sampling locations

	Outdoor air	Atm. deposition	Sediment	Biota	Water from fires	Influent	Effluent	Sludge	Storm water	Indoor air	Dust	Human serum	Total
<b>Background sites</b>													
Råö	6	6											12
Pallas	2												2
Väderöarna				1									1
Kullen				1									1
Fladen				1									1
Koster			1										1
<b>Urban sites</b>													
Göteborg, Järntorget	4												4
Göteborg, Björkö			1	1									2
Göteborg, Stockholmen			1	1									2
Göteborg, Eriksberg			1	1									2
Göteborg, Lilla Varholmen				1									1
Göteborg, Linnégatan									1				1
Göteborg, Gårda									1				1
Göteborg, Odinsplatsen									1				1
Göteborg, Ryaverket WWTP						1	1	1					3
Borås, Gässlösa WWTP							1	1					2
<b>Point sources</b>													
Recycling electronic waste										2	2		4
Unintentional fire, recycling facility					3								3
Private car											1		1
<b>Indoor environment</b>													
Public and private spaces											5		5
<b>Human exposure</b>													
Human serum												15	15
<b>Total</b>	<b>12</b>	<b>6</b>	<b>4</b>	<b>7</b>	<b>3</b>	<b>1</b>	<b>2</b>	<b>2</b>	<b>3</b>	<b>2</b>	<b>8</b>	<b>15</b>	<b>65</b>



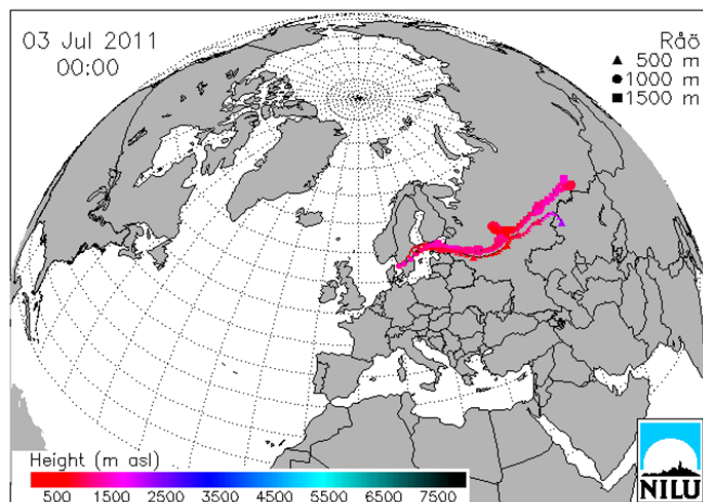
**Table 5.** Sampling programme for PBDFs, number of samples at the different sampling locations

	Outdoor air	Atm. deposition	Water from fires	Influent, STP	Effluent, STP	Sludge, STP	Storm water	Storm water sludge	Plastics	Indoor air	Dust	Human milk	Total
<b>Background sites</b>													
Råö	16	6											22
Pallas	2												2
<b>Urban sites</b>													
Göteborg, Järmtorget	4												4
Göteborg, Linnégatan								1					1
Göteborg, Gårda								1					1
Göteborg, Odinsplatsen								1					1
Göteborg, Ryaverket WWTP				1	1	1							3
Borås, Gässlösa WWTP				1	1	1							3
<b>Point sources</b>													
Recycling electronic waste									2	2	3		7
Unintentional fire: recycling facility			3										3
Private car											1		1
<b>Indoor environment</b>													
Public and private spaces											5		5
<b>Human exposure</b>													
Human milk												10	10
<b>Total</b>	<b>22</b>	<b>6</b>	<b>3</b>	<b>2</b>	<b>2</b>	<b>2</b>	<b>0</b>	<b>3</b>	<b>2</b>	<b>2</b>	<b>9</b>	<b>10</b>	<b>63</b>

### 3.1.2 Trajectory study- Selection of samples for the analyses of PBDFs.

Flextra trajectory plots<sup>1</sup>, available at Norwegian Institute for Air Research (NILU), were used to evaluate the travel path of the air masses with the arrival at Råö. The Flextra trajectory plots are calculated four times a day (0:00, 6:00, 12:00 and 18:00). Each trajectory spans over seven days. Each plot gives three trajectories with three different heights (500, 1000 and 1500 m above sea level). Each 3-hour interval along the trajectory path is indicated by a small legend, each 24-hour interval by a big legend (**Figure 3**).

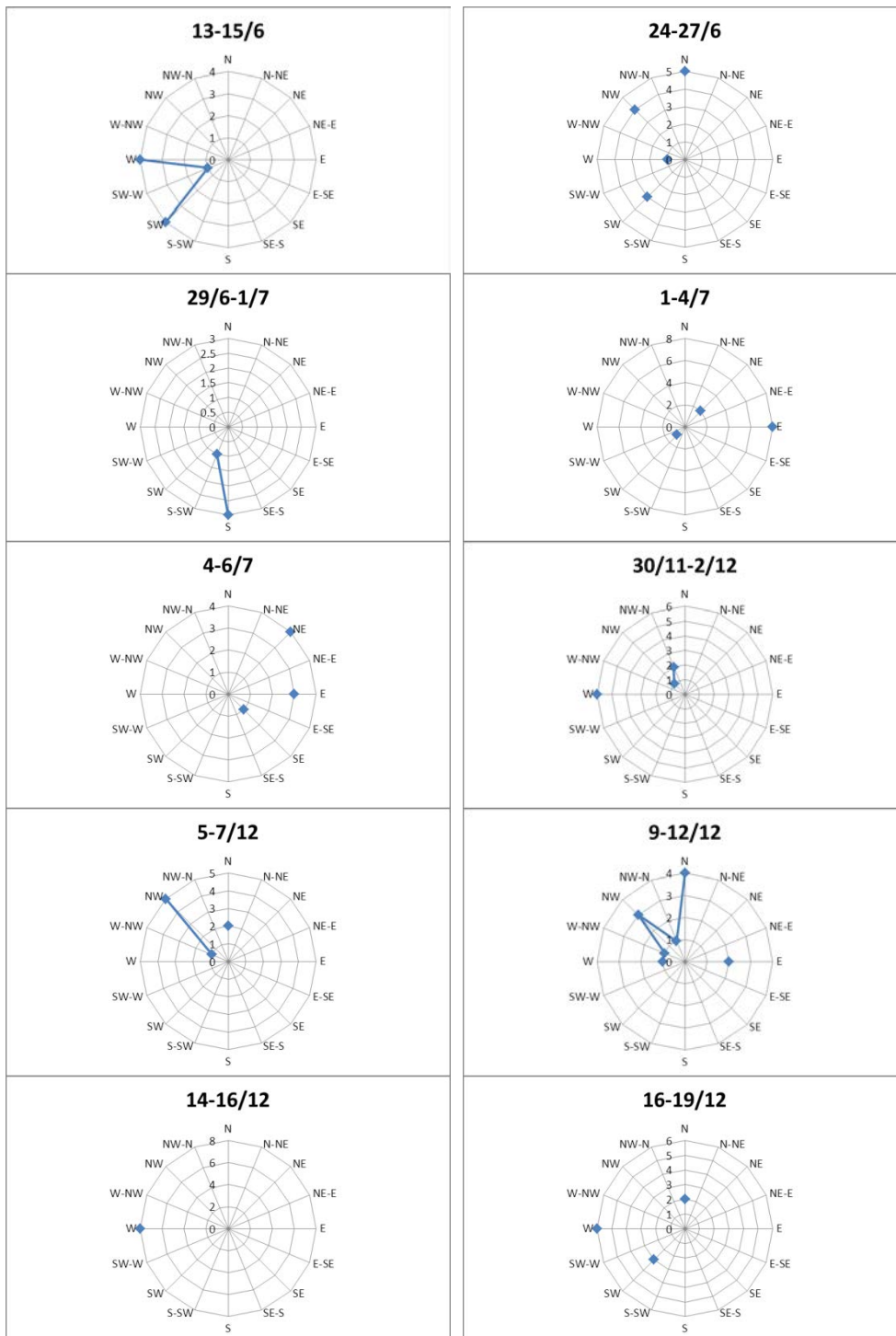
<sup>1</sup> <http://www.nilu.no/projects/ccc/trajectories/>



**Figure 3.** Example of Flextra trajectory plot. Each 3-hour interval along the trajectory pathway is indicated by a small legend, each 24-hour interval by a big legend

Trajectories with a span of 72 hours back in time at 500 m above sea level were used. During each sampling period, 2-3 days, between 8 and 12 trajectory plots were generated. The origin of the air masses for each period was plotted as a radar chart plot, which was divided in sectors arranged by the point of the compass. In Figure 4 the chart plots for the 10 selected samples are presented. The plots show from which sector the air masses originate from.

The selection of samples for analysis of PBDFs and the main transport direction sector are shown in **Table 6**.



**Figure 4.** Radar chart plots for the selected sampling periods. The charts show the origin of the air masses 72 hours before arrival to Råö, at 500 m asl at arrival site. The most frequent origin of the air masses is presented as number of trajectories for each sampling period (maximum frequent number 8 to 12) from respective sector, e.g. W and SW during 13-15/6.

**Table 6.** Samples selected for analyses of PBDFs and the main transport direction sector

Date	Most frequent sector of air masses	Transport route
13-15/6	W, SW	Ireland/GB and Spain/France.
24-27/6	N, NW	The first part of the period from Barents Sea, later on from Ireland/GB
29/6-1/7	S, S-SW	Circulation of air above Germany and Denmark
1-4/7	E	Russia and over Finland
4-6/7	E, NE	Finland, Baltic states, at the end of the period as a loop from Poland via the Baltic states and Finland
30/11-2/12	W	Start at Greenland, via Ireland/GB or north of Ireland/GB
5-7/12	NW	Start at Greenland/Island, Not much circulation of air, long transports
9-12/12	N, NW	Start in the north or north-west with circulation around Sweden, Norway and at the end of the period above the Baltic states
14-16/12	W	Ireland/GB and via Spain and Germany.
16-19/12	W	Ireland/GB, at the end of the period as a loop via France, Poland, Baltic states and Finland

## 4 Methods

### 4.1 Sampling

**Air:** The outdoor air samples were collected using a high volume air sampler (HVS). A glass fibre filter was used for trapping the particles followed by an adsorbent of polyurethane foam (PUF) for collecting compounds in the gas phase. The air sampling was carried out weekly and sample extracts were then combined to represent longer time periods. At Råö short-time air sampling (2-3 days) was also performed. The approximate air flow was 26 m<sup>3</sup>/hour. All samples were stored at -18 °C until analyses. BFRs and PBDFs were analysed using the same sample

**Indoor air:** Indoor air samples were collected using a low volume air sampler (LVS), in which the air was passing through a glass fibre filter and then through a glass column packed with adsorbent (PUF). The sampling time for indoor air was approximately one week. The approximate air flow was 1.3 m<sup>3</sup>/hour. All samples were stored at -18 °C until analyses. The BFRs and PBDFs were analysed in the same sample.

**Dust:** Dust samples were collected with a re-built vacuum cleaner. The inflow of the vacuum cleaner (nozzle) was equipped with a glass fibre filter for trapping the particles. The samples were collected during approximately 10-15 minutes (for more information, see Appendix 1). The filters were conditioned at controlled temperature and humidity conditions for 24 hours and weighed both before and after the sampling. The filters were stored in a freezer (-18 °C) until analysed. Separate samples were collected for the determination of BFRs and PBDFs.

**Atmospheric deposition:** Both wet and dry deposition was collected using an open sampler (bulk sampler). This sampler consisted of a 1 m<sup>2</sup> Teflon coated surface with 10 cm high edges. The bottom declined slightly to a central opening where a cassette with an adsorbent of PUF was attached. After sampling, the sampler was cleaned with ethanol and filters. The deposition sample included both compounds in the precipitation and compounds deposited to the collection surface of the sampler together with the ethanol rinse. Both the precipitation and the deposited particles were included in the analysis. The sampling duration was one to two weeks. Sample extracts were combined to represent longer time periods. All samples were stored at -18 °C until analysed. The BFRs and PBDFs were analysed in the same sample.

**Sediment:** The surface sediments (0-2 cm) from Göta älv, Göteborg, were provided by Marine Monitoring at Kristineberg AB. A ponar type grab sampler was used. One sediment samples were collected at a remote area in Skagerrak within the Swedish national monitoring programme of marine sediments by the Geological Survey of Sweden (SGU). This sediment (0-24 cm) was collected with a boxcore sampler at a water depth of 95 m. All samples were stored at -18 °C in pre-cleaned glass jars.

**Biota:** Herring muscle samples from the Swedish west coast (Kullen, Fladen and Väderöarna) were provided from the specimen bank at the Swedish Museum of Natural History. The fish muscle samples consisted of a homogenate of 10 individuals. Molluscs (netted dog whelk) from Göta älv were provided by Marine Monitoring at Kristineberg AB. The molluscs were caught in a special trap with dead fish used as bait. All samples were stored at -18 °C in pre-cleaned glass jars.

**Storm water** was sampled at three sites close to traffic roads in Göteborg. The samples were provided by the City of Göteborg "Park and Nature Management". The storm water was collected in pre-cleaned glass bottles and stored in refrigerator (4 °C). Storm water sludge was collected with a bucket and stored in pre-cleaned glass jars at -18 °C. Separate samples were collected for the determination of BFRs and PBDFs.

**WWTP, water and sludge:** The staff at the different STPs collected de-watered sludge samples from the anaerobic chambers. The sludge was transferred into glass jars and stored in a freezer (-18 °C) until analysed. Influent and effluent water samples were collected in pre-cleaned glass bottles. Separate samples were collected for the determination of BFRs and PBDFs.

**Fire samples:**

Water samples were collected manually shortly after a fire at an electronic waste handling facility in northern Sweden. The samples were homogenized thoroughly and divided for analysis at UmU and IVL.

**Human serum:** Venous blood was sampled from healthy volunteers using evacuated tubes containing acrylic based gel and a spray-dried trombin based clot activator coating

(Vacutainer 368498, BD Diagnostics). After centrifugation the serum was transferred to a polypropylene tube and stored in a freezer.

#### **Human milk:**

Human milk samples were collected by the National Food Agency (Livsmedelsverket) as part of their annual monitoring and banking program for polychlorinated dibenzo-*p*-dioxins and dibenzofurans. The samples were stored frozen until the time for analysis.

## **4.2 Analysis BFRs**

### **4.2.1 Chemicals**

HBB, PBT and DBDPE were bought from Sigma-Aldrich. TBEC and PBEB were purchased from Chiron As, Trondheim, Norway. BDE-166, BDE-190 and 4-fluoro-nonabromo biphenyl ether (4-F-BDE-208) was used as recovery standards were purchased from Chiron As Trondheim Norway.

### **4.2.2 Equipment**

All equipment made of Teflon or metal was washed with solvent before use. Solvents used for extraction were delivered from Rathburn (Chemical Ltd., Peeblesshire, Scotland). Silica gel (Merck), glass equipment and GF/C-filters were muffled at 400°C in 8 hours prior to use. PUF-columns were pre-extracted in a Soxhlet apparatus before use.

### **4.2.3 Sample preparation**

#### *Air and deposition*

Air (indoor and outdoor) and deposition samples were extracted in accordance with the methods used in the monitoring program for air pollutants. The samples (PUF-plugs and filters) were Soxhlet extracted with acetone for 24±2 hours. Extracts from the adsorbent and filter were combined and divided for determination of the different substance groups. The solvent was exchanged to hexane before clean-up (see below). The final extract was spiked with an internal standard mixture. An additional Soxhlet extraction with toluene was undertaken for the air and deposition samples for analysis of PBDFs.

#### *Water*

Water was filtered through a GF/C-filter; the filter was extracted separately (see below). The filtrate was spiked with internal standard and concentrated on a C<sub>18</sub> SPE column. Methanol and DCM was used to elute the analytes. The GF/C filter was extracted with methanol and DCM and the extract was pooled with the SPE-eluate. The methanol was washed away by extraction with water. The solvent was dried and exchanged to hexane before clean-up (see below).

#### *Sludge and sediment*

Samples of sediment and sludge were freeze dried before extraction with DCM for 8 hours. Internal standards were added before extraction. The solvent was exchanged to hexane before clean-up (see below).

#### *Biological tissue*

The sample was spiked with internal standards and homogenized (Ultra Turrax) in DCM: acetone. The extraction was performed overnight on a reciprocating shaker. The second extraction was performed with hexane: MTBE and lasted for 1 h. The combined extract was shaken with water to remove the acetone. The solvent was exchanged to hexane before clean-up (see below).

#### *Dust samples*

Dust was extracted with DCM (8 hours) on a reciprocating shaker. Internal standards were added before extraction. The extraction was repeated with hexane: MTBE. The solvent was exchanged to hexane before clean-up (see below).

#### *Clean-up of extracts*

The hexane extract was treated twice with concentrated sulphuric acid to followed by chromatography on a silica-H<sub>2</sub>SO<sub>4</sub> (conc. sulphuric acid:silica 1:2 w.w.) column using DCM as mobile phase (Hovander *et al.*, 2000). Before instrumental analysis the extract was concentrated to between 100 and 500 µl.

#### *Instrumental analysis*

The extracts were analysed on a 7890A gas chromatograph coupled to a 7000A Triple Quad MS (Agilent Technologies, Inc. Santa Clara, CA, USA). The injection was made pulsed splitless at 250°C. For TEBC, HBB, PBT and PBEB a fused silica capillary column (VF-5MS 30 m x 0.25 mm i.d. x 0.25 µm film thickness, Varian) was used. The temperature program was as follows: 50°C for 1 min, ramped 15°C/min to 250°C, then 5°C/min to 300 °C.

For the BDE-209 and DBDPE a DB5-MS column (15 m x 0.25 mm i.d., 0.1 µm film thickness, Agilent) was used. The injector temperature was 275°C. The temperature program started at 100°C and was held for 1 min. The temperature was ramped 25°C/min to 320°C and held for 8 min. The transfer line was held at 280°C. Helium was used as carrier gas. The detector was used in negative chemical ionisation SIR mode with methane as reagent gas. The analytes were identified by their characteristic retention times and two ions. Quantification was based on comparison of peak abundance to the known response of the internal standard (BDE-190). The instrument was calibrated with a six point calibration curve. The reported analyte concentrations were calculated according to the determined surrogate standard.

### **4.2.4 Quality control**

When performing environmental screening all steps in the study such as selection of sampling site, sampling frequency, time of sampling, performing of sampling, transport and storage of samples, chemical analysis and data treatment are generating some degree of

uncertainty. To quantitatively estimate the contribution of all steps is an extremely difficult task or not possible at all. However, we will discuss the relevance of the different contributors in a qualitative way.

One important question is whether a sample is representative for a given time period or a given region. Many of the selected compounds are intermittently emitted to the environment and a constant concentration of these compounds in the environment is not expected. In this screening, the samples were collected within a narrow time frame and at different geographical locations. The results obtained here are therefore only a snapshot of the reality at those places at the given time.

Factors with influence on sampling uncertainty are analyte loss due to adsorption to sample containers, wastewater flow and particle content, tidal water current, contamination and degradation during transport and storage. The uncertainty due to loss of analyte is minimised (especially for water samples) by the laboratory's selection of sample containers.

The uncertainty of the chemical analysis is governed by loss during extraction and clean-up, interference from other compounds, trueness of analytical standards, instrumental parameters, and contamination.

The following quality criteria were used to ensure correct identification and quantification of the target compounds: (a) the retention times should match those of the standard compounds within  $\pm 0.05$  min., (b) the intensity ratios of the selected MRMs should be within  $\pm 15$  % of that observed for the standard compounds (c) the signal-to-noise ratios should be greater than 3:1.

Field blanks were collected at several sampling stations. An analytical method blank was included for each sample batch to assess background interferences and possible contamination of the samples. Concentrations below field blank levels were treated as not detected. Possible background levels of analytes were subtracted from measured sample values.

Limit of quantification (LOQ) was defined as a signal 10 times the standard deviation of the blank values. Internal standard was added to the sample at the start of the working-up procedure. The internal standard has similar chemical and physical properties as the compounds to be analysed.

## 4.3 Analysis of PBDFs

### 4.3.1 Sample preparation and analysis

PBDD/Fs are structural analogues to polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) and behave similarly during extraction and clean up. Therefore the standard PCDD/F protocols that are used for SS/EN 17025 accredited analysis were used for sample preparation. Analysis were performed using gas



chromatography – high resolution ( $\geq 10\,000$ ) mass spectrometry (GC-HRMS) with electron ionization and selected ion recording (SIR). A short GC column was used to elute the high boiling PBDD/Fs in a reasonable time and to avoid thermal decomposition.

### 4.3.2 Quality control

For a positive identification the sample components had to elute within the GC time windows of the corresponding standard substances and have an isotope ratio of two monitored SIR ions (for each compound class and degree of halogenation) that differed no more than 10% from the theoretical value. In addition, the blank should contain none or negligible quantities of target analytes.

The quantification was performed by the isotope dilution technique, using  $^{13}\text{C}$ -labelled PBDD/F internal standards.

Blanks were run in parallel to samples to estimate the degree of field and laboratory background. The background was generally low and no background correction was made.

## 5 Results

All measured concentrations or limits of quantification (LOQs) for individual substances in all samples are tabulated in Appendix 2-6. The LOQs varies among the different substances in different matrices, due to factors such as varying sample amounts, analytical interferences and instrumental response.

An overview of the detection frequencies, *i.e.* the fraction of samples where a substance was found in a concentration above the limit of quantification (LOQ) for different sample matrices, are given in **Table 7** a-d and **Table 8** a-d.

The screening includes about 60 samples but with only a few samples representing different media, different locations and different time periods. Some of the sample matrices have only been sampled occasionally e.g. the samples from WWTPs, and the dust samples represent different indoor environments. In addition the LOQs vary as a consequence of matrices, measurement methods, sample volumes/amounts and varying analytical interferences etc. The detection frequencies are therefore intended only as an overview of the results.

**Table 7 a.** Detection frequencies (%) of individual BFRs in different environmental matrices.

Matrix	Air	Atm. Dep.	Sediment	Biota
<b>BFR</b>				
No of samples:	12	6	4	7
HBB	50%	0%	25%	57%
PBT	25%	0%	25%	0%
PBEB	17%	0%	25%	100%
DBDPE	0%	0%	0%	0%
TBECH	33%	0%	0%	29%

**Table 7 b.** Detection frequencies (%) of PBDDs and PBDFs in different environmental matrices.

Matrix	Air	Atm. Dep.
<b>PBDDs</b>		
No of samples:	22	6
2378-TBDD	91%	100%
12378-PeBDD	82%	50%
123478+123678-HxBDD	73%	33%
123789-HxBDD	64%	0%
1234678-HpBDD	82%	100%
OctaBDD	9%	33%
<b>PBDFs</b>		
2378-TBDF	95%	100%
12378-PeBDF	59%	100%
23478-PeBDF	82%	17%
123478-HxBDF	86%	83%
1234678-HpBDF	100%	100%
OctaBDF	91% <sup>1</sup>	100% <sup>2</sup>

<sup>1</sup>11 samples; <sup>2</sup>3 samples

**Table 7 c.** Detection frequencies (%) of PCDD/PCDFs in different environmental matrices.

Matrix	Air	Atm. Dep.
<b>PCDDs</b>		
<i>No of samples:</i>	22	6
<b>2378 TeCDD</b>	27%	17%
<b>12378 PeCDD</b>	55%	50%
<b>123478 HxCDD</b>	36%	33%
<b>123678 HxCDD</b>	41%	67%
<b>123789 HxCDD</b>	59%	50%
<b>1234678 HpCDD</b>	86%	100%
<b>OCDD</b>	91%	100%
<b>PCDFs</b>		
<b>2378 TeCDF</b>	95%	100%
<b>12378 PeCDF</b>	86%	100%
<b>23478 PeCDF</b>	91%	83%
<b>123478 HxCDF</b>	64%	83%
<b>123678 HxCDF</b>	55%	83%
<b>234678-HxCDF</b>	73%	83%
<b>123789-HxCDF</b>	73%	83%
<b>1234678 HpCDF</b>	91%	100%
<b>1234789 HpCDF</b>	50%	67%
<b>OCDF</b>	64%	67%

**Table 7 d.** Detection frequencies (%) of PBDEs in different environmental matrices.

Matrix	Air	Atm. Dep.	Sediment	Biota
<b>PBDE</b>				
<i>No of samples:</i>	13	7	4	7
<b>BDE-28</b>	100%	100% <sup>1</sup>	- <sup>2</sup>	- <sup>2</sup>
<b>BDE-47</b>	100%	100%	25%	100%
<b>BDE-100</b>	85%	86%	25%	86%
<b>BDE-99</b>	100%	100%	25%	100%
<b>BDE-154</b>	100%	100% <sup>1</sup>	- <sup>2</sup>	- <sup>2</sup>
<b>BDE-153</b>	100%	100% <sup>1</sup>	- <sup>2</sup>	- <sup>2</sup>
<b>BDE-183</b>	100%	100% <sup>1</sup>	- <sup>2</sup>	- <sup>2</sup>
<b>BDE-209</b>	85%	100% <sup>1</sup>	100%	43%

<sup>1</sup>6 samples; <sup>2</sup>No data

**Table 8 a.** Detection frequencies (%) of BFRs in for matrices representing sources and pathways.

Matrix	Influent, WWTP	Effluent, WWTP	Sludge, WWTP	Storm water	Fire extinguishing water	Dust	Indoor air, industrial	Plastics
<b>BFR</b>								
<i>No of samples:</i>	1	2	2	3	3	8	2	2
HBB	0%	0%	100%	100%	100%	88%	100%	- <sup>2</sup>
PBT	100%	0%	100%	33%	33%	100% <sup>1</sup>	100%	- <sup>2</sup>
PBEB	100%	0%	100%	67%	67%	29% <sup>1</sup>	50%	- <sup>2</sup>
DBDPE	0%	50%	100%	100%	100%	100%	100%	- <sup>2</sup>
TBECH	0%	0%	0%	0%	0%	38%	100%	- <sup>2</sup>

<sup>1</sup> 7 samples; <sup>2</sup> No data

**Table 8 b.** Detection frequencies (%) of PBDD/PBDFs in matrices representing sources and pathways.

Matrix	Influent, WWTP	Effluent, WWTP	Sludge, WWTP	Storm water	Storm water sludge	Fire extinguishing water	Dust	Indoor air, industrial	Plastics
<b>PBDDs</b>									
<i>No of samples:</i>	2	2	2	3	3	3	9	2	2
2378-TBDD	50%	100%	100%	- <sup>4</sup>	100%	0%	100%	100%	100%
12378-PeBDD	100%	50%	50%	- <sup>4</sup>	100%	0%	100%	50%	100%
123478+123678-HxBDD	100%	0%	50%	- <sup>4</sup>	67%	0%	78%	50%	100%
123789-HxBDD	100%	0%	100%	- <sup>4</sup>	0%	0%	78%	50%	100%
1234678-HpBDD	100%	0%	100%	- <sup>4</sup>	0%	67%	89%	100%	100%
OctaBDD	50%	0%	100%	- <sup>4</sup>	0%	100%	75% <sup>1</sup>	100%	100%

**Table 8 b. cont.** Detection frequencies (%) of PBDD/Fs in matrices representing sources and pathways.

Matrix	Influent, WWTP	Effluent, WWTP	Sludge, WWTP	Storm water	Storm water sludge	Fire extinguishing water	Dust	Indoor air, industrial	Plastics
<b>PBDFs</b>									
2378-TBDF	100%	100%	100%	- <sup>4</sup>	100%	100%	100%	100%	100%
12378-PeBDF	100%	100%	100%	- <sup>4</sup>	100%	100%	100%	100%	100%
23478-PeBDF	100%	100%	100%	- <sup>4</sup>	100%	100%	100%	100%	100%
123478-HxBDF	100%	100%	100%	- <sup>4</sup>	67%	100%	100%	100%	100%
1234678-HpBDF	100%	100%	100%	- <sup>4</sup>	100%	100%	100%	100%	100%
OctaBDF	0% <sup>2</sup>	50%	- <sup>4</sup>	- <sup>4</sup>	- <sup>4</sup>	100%	100%	100% <sup>3</sup>	100%

<sup>1</sup> 8 samples; <sup>2</sup> 1 sample; <sup>3</sup> 7 samples; <sup>4</sup> No data

**Table 8 c.** Detection frequencies (%) of PCDD/PCDFs in matrices representing sources and pathways.

Matrix	Influent, WWTP	Effluent, WWTP	Sludge, WWTP	Storm water	Storm water sludge	Fire extinguishing water	Dust	Indoor air, industrial	Plastics
<b>PCDDs</b>									
<i>No of samples:</i>	2	2	2	3	3	3	9	2	2
<b>2378 TeCDD</b>	0%	0%	0%	100%	33%	0%	67%	0%	0%
<b>12378 PeCDD</b>	0%	0%	50%	100%	33%	67%	67%	0%	50%
<b>123478 HxCDD</b>	0%	0%	50%	100%	0%	67%	33%	0%	0%
<b>123678 HxCDD</b>	0%	0%	100%	100%	100%	100%	67%	0%	0%
<b>123789 HxCDD</b>	0%	0%	50%	100%	67%	100%	56%	0%	0%
<b>1234678 HpCDD</b>	100%	50%	100%	100%	100%	100%	100%	0%	100%
<b>OCDD</b>	100%	100%	100%	100%	100%	100%	100%	0%	100%
<b>PCDFs</b>									
<b>2378 TeCDF</b>	100%	100%	100%	100%	100%	100%	89%	100%	100%
<b>12378 PeCDF</b>	0%	50%	100%	100%	67%	100%	67%	0%	100%
<b>23478 PeCDF</b>	50%	50%	100%	100%	100%	100%	56%	0%	100%
<b>123478 HxCDF</b>	0%	0%	100%	100%	100%	100%	67%	0%	100%
<b>123678 HxCDF</b>	0%	0%	100%	100%	100%	100%	56%	0%	50%
<b>234678-HxCDF</b>	0%	0%	100%	100%	100%	100%	89%	0%	100%
<b>123789-HxCDF</b>	0%	0%	100%	100%	100%	100%	44%	0%	100%
<b>1234678 HpCDF</b>	100%	50%	100%	100%	100%	- <sup>1</sup>	89%	0%	100%
<b>1234789 HpCDF</b>	0%	0%	100%	100%	100%	100%	44%	0%	50%
<b>OCDF</b>	0%	0%	100%	100%	100%	100%	89%	0%	100%

<sup>1</sup> No data

**Table 8 d.** Detection frequencies (%) of PBDEs in matrices representing sources and pathways.

Matrix	Influent, WWTP	Effluent, WWTP	Sludge, WWTP	Storm water	Fire extinguishing water	Dust	Indoor air, industrial	Plastics
<b>BFR</b>								
<i>No of samples:</i>	1	2	2	3	3	9	2	2
<b>BDE-28</b>	- <sup>2</sup>	- <sup>2</sup>	- <sup>2</sup>	100% <sup>1</sup>	100%	100%	100%	100%
<b>BDE-47</b>	100%	100%	100%	100%	100%	100%	100%	100%
<b>BDE-100</b>	100%	50%	100%	100%	100%	100%	100%	100%
<b>BDE-99</b>	100%	100%	100%	100%	100%	100%	100%	100%
<b>BDE-154</b>	- <sup>2</sup>	- <sup>2</sup>	- <sup>2</sup>	100% <sup>1</sup>	100%	100%	100%	100%
<b>BDE-153</b>	- <sup>2</sup>	- <sup>2</sup>	- <sup>2</sup>	100% <sup>1</sup>	100%	100%	100%	100%
<b>BDE-183</b>	- <sup>2</sup>	- <sup>2</sup>	- <sup>2</sup>	100% <sup>1</sup>	100%	100%	100%	100%
<b>BDE-209</b>	100%	100%	100%	100%	100%	100%	100%	100%

<sup>1</sup> 1 sample; <sup>2</sup> No data

In general several of the emerging BFRs (Table 7 a) occurred in all the included environmental matrices except in the atmospheric deposition. However there were differences among the substances and their occurrence in different environmental media. DBDPE was not detected at all.

PBDEs were regularly found in all the environmental matrices indicating their widespread distribution in the environment (Table 7 b). However there were some differences among the congeners.

The brominated and the chlorinated dioxins and furans were only measured in air and deposition where PBDDs and PBDFs (Table 7 c) like PCDD and PCBFs (Table 7 d) frequently were detected but there was a variation among the different congeners. PBDFs showed generally high detection frequencies.

The emerging BFRs were generally found in samples from WWTPs, storm water, indoor air and dust as well as in samples from the recycling industry indicating that these substances may be emitted and transported to the environment via these sources and pathways (Table 8 a). Like the occurrence of the BFRs in the environmental matrices there were differences among the individual substances and the different matrices.

PBDEs were identified in all samples representing sources and pathways (Table 8 b).

Like the BFRs, PBDDs were detected in samples from WWTPs, storm water sludge, indoor air and dust, but the detection frequencies varied a lot among the congeners. PBDF however showed high detection frequencies, 100%, for all the congeners in most of the matrices

In the following, the concentrations found are presented in more detail.

## 5.1 Brominated flame retardants (BFRs)

### 5.1.1 Point sources

The concentrations of BFRs in indoor air and dust collected at a recycling industry for electronic waste are given in Table 9.

All the included BFRs were found both in the industrial indoor air (gas and particles) and in the dust samples, but with great variation in the concentrations. HBB, DBDPE and BDE-209 occurred in the highest concentrations, HBB dominating in air, DBDPE and BDE-209 in dust. The concentrations of DBDPE and BDE-209 were mostly in the same level, except in one of the dust samples which contained as much as 400 000 ng/g of BDE-209. The levels of the other emerging BFRs were in following order: PBT > PBEB > TBECH. The concentrations of HBB were generally higher compared to BDEs 47, 100 and 99, while the TBECH concentrations were lower.

**Table 9.** Concentrations of BRFs in indoor air and in dust from recycling industry, electronic waste.

Site	Matrix	Unit	HBB	PBT	PBEB	DBDPE	TBECH	BDE-47	BDE-100	BDE-99	BDE-209
Disassembly hall, week 1	Air	pg/m <sup>3</sup>	1600	14	<11	220	8.3	50	4.5	22	520
Disassembly hall, week 2	Air	pg/m <sup>3</sup>	1400	25	12	530	6.7	51	4.5	21	480
Sorting belt <sup>1</sup>	Dust	ng/g	8200	64	16	23000	2.8	600	106	1400	22000
Truck <sup>2</sup>	Dust	ng/g	1200	5.4	9.1	20000	1.3	660	130	1000	400000

<sup>1</sup>Sorting belt - the area on which electronic waste was disassembled and sorted.

<sup>2</sup>Truck - dust from truck used in the disassembly hall for moving the waste between storage areas and sorting belt. The dust was collected from inside the truck.

All BFRs, but TBECH, were found in the extinguishing water from the fire fighting of electronic waste (Table 10). Like in the air and dust samples from the recycling of electronic waste facility, DBDPE and BDE-209 occurred in the highest concentrations. The levels of HBB were higher compared to BDE- 47, -100 and -99.

**Table 10.** Concentrations of BRFs in fire extinguishing water from recycling of electronic waste.

Site	Matrix	Unit	HBB	PBT	PBEB	DBDPE	TBECH	BDE-47	BDE-100	BDE-99	BDE-209
Pond 1, extinguishing water	Water	ng/L	1200	4.2	16	1600	<2	86	12	85	2700
Pond 2, extinguishing water	Water	ng/L	440	<2	4.4	330	<2	74	12	79	3700
On-going fire-fighting	Water	ng/L	11	<2	<2	1800	<2	69	8	68	1700

The concentrations of the BFRs found in a dust sample collected in a “new private car” are given in Table 11. The concentration of BDE-209 was as high as 3 600 000 ng/g (3.6 mg/g). Of the emerging BFRs DBDPE was found in the highest concentration (92 000 ng/g). HBB, PBT, BDE-47, -100 and -99 was also found, but in a three orders of magnitude lower concentration range.

The dust was collected from surfaces inside the car, the walls, roof, dashboard and seats. This car was selected randomly and we do not know how representative these dust concentrations are for other cars.

**Table 11.** Concentrations of BFRs in dust from a “new” car.

Site	Matrix	Unit	HBB	PBT	PBEB	DBDPE	TBECH	BDE-47	BDE-100	BDE-99	BDE-209
New car	Dust	ng/g	80	42	<43	92000	<11	56	15	84	3600000

### 5.1.2 BFRs in indoor dust

The concentrations of the BFRs found in indoor dust are given in Table 12. DBDPE and BDE-209 occurred in considerably higher concentrations compared to the other BFRs, which is similar to the content samples from point sources. Of the other emerging BFRs, HBB occurred in the highest concentrations, which mostly were higher or in the same concentration levels as the penta-BDEs. The concentrations of PBEB were below the limit of quantification (LOQ). However the LOQ for this substance is rather high. TBECH was detected in one of the samples.

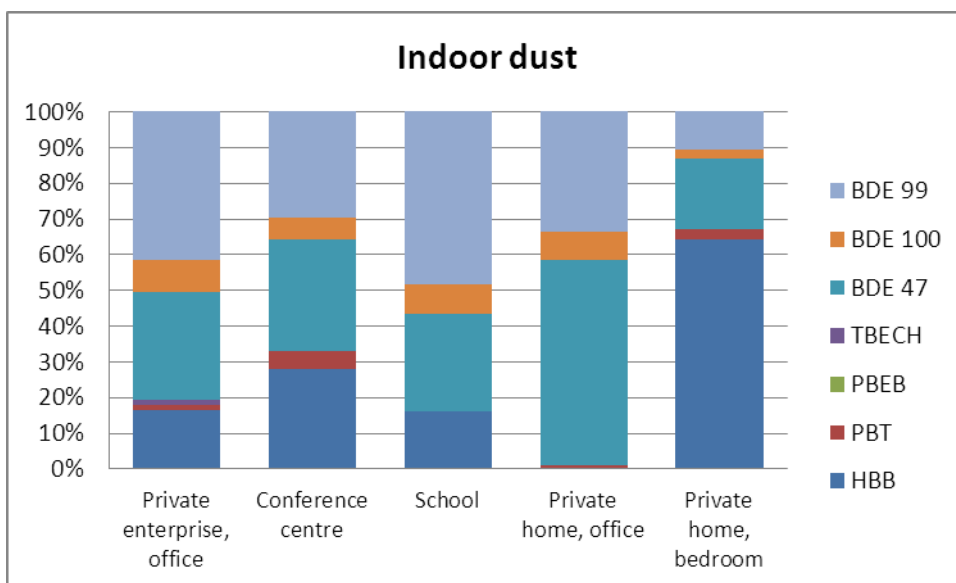
**Table 12.** Concentrations of BFRs in dust from indoor spaces.

	Unit	HBB	PBT	PBEB	DBDPE	TBECH	BDE-47	BDE-100	BDE-99	BDE-209
Private enterprise, office	ng/g	16	1.5	<5	4000	1.3	29	8.4	40	11000
Conference centre	ng/g	11	2	<3	8100	<0.71	12	2.5	12	720000
School	ng/g	10	interf.	interf.	140	<0.87	17	5.2	30	430
Private home, office	ng/g	<7.5	0.72	<5.0	1300	<1.2	36	5.0	21	120
Private home, bedroom	ng/g	20	0.9	<3.0	680	<0.76	6.2	0.80	3.3	110

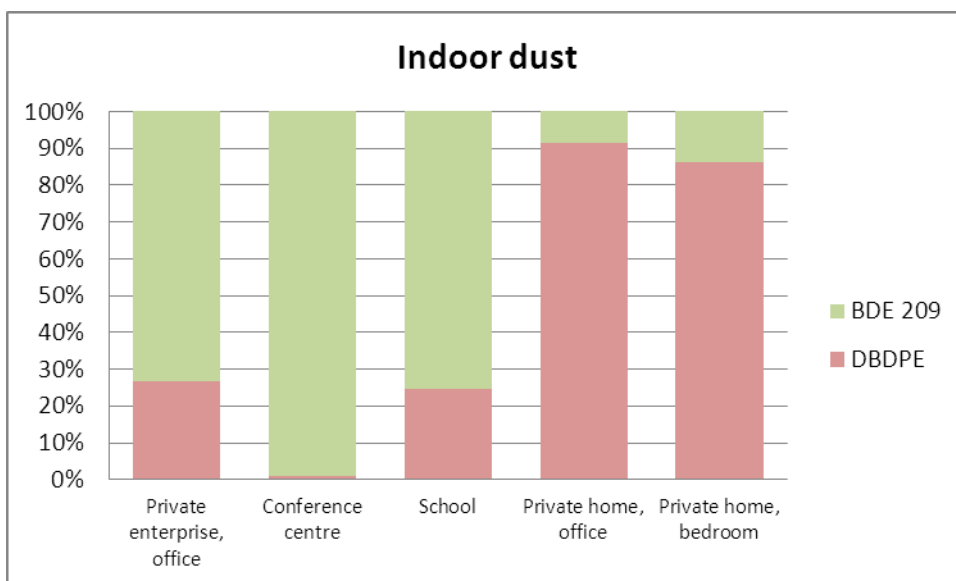
The distribution among the BFRs varied for the dust samples from the different indoor environments, see **Figure 5** and **Figure 6**. These relative concentration differences were most significant for DBDPE and BDE-209.

Several studies, carried out world wide, have published data concerning DBDPE concentrations in indoor dust samples, (EFSA 2012). Similar to this screening, DBDPE is frequently found and with great variation in concentrations. Harrad *et al.*, (2008), who studied the DBDPE occurrence in dust from UK homes offices and cars, reported concentrations between <10 and 11 070 ng/g.





**Figure 5.** Distribution of BFRs in dust from indoor spaces (DBDPE and BDE-209 excluded).



**Figure 6.** Distribution of DBDPE and BDE-209 in dust from indoor spaces

The result of the dust measurements indicate that diffuse emissions of BFRs from consumer products may occur in indoor environments. The differences in the distribution of BFRs among the different dust samples indicate that BFRs in dust originates from different consumer products and articles.

### 5.1.3 BFRs in storm water and in waste water treatment plants

The concentrations of the BFRs in storm water collected at streets in central Göteborg are given in **Table 13**.

**Table 13.** Concentrations of BFRs in storm water.

Site	Unit	HBB	PBT	PBEB	DBDPE	TBECH	BDE-47	BDE-100	BDE-99	BDE-209
Linnégatan, Göteborg	ng/L	2.2	<2	<2	250	<2	2.6	1.3	11	290
Gårda, Göteborg	ng/L	14	<2	7.7	1300	<2	19	7.8	28	270
Odinsplatsen, Göteborg	ng/L	22	2.2	91	1500	<2	100	33	230	31000

DBDPE and BDE-209 were found in significantly higher concentrations compared to the other BFRs. HBB occurred in all three storm water samples and the concentrations were in the same order of magnitude as the penta-BDEs. There was a variation in the concentrations of the BFRs among the different sites with the highest concentrations at Odinsplatsen, the site with the highest traffic intensity.

The concentrations of BFRs in influent, effluent and sludge from municipal WWTPs are given in **Table 14**.

**Table 14.** Concentrations of BFRs in samples from WWTPs.

Site	Matrix	Unit	HBB	PBT	PBEB	DBDPE	TBECH	BDE-47	BDE-100	BDE-99	BDE-209
Ryaverket WWTP	Influent	ng/L	<1.4	2.4	9.9	<70	<1.4	21	4.3	26	12000
Ryaverket WWTP	Effluent	ng/L	<1	<1	<1	<50	<1	10	1.7	9.6	360
Ryaverket WWTP	Sludge	ng/g dw	1.6	0.14	0.64	63	<0.22	15	4.7	1.9	2700
Gässlösa WWTP	Effluent	ng/L	<1	<1	<1	420	<1	0.77	<0.1	0.53	19
Gässlösa WWTP	Sludge	ng/g dw	0.49	0.6	0.43	190	<0.1	33	11	2.1	820

The influent from Ryaverket WWTP contained PBT, PBEB and PBDEs while the other substances were below the LOQ. The levels of the emerging BFRs in the effluent from Ryaverket were below the LOQs while the effluent from Gässlösa contained increased concentrations of DBDPE. All BFRs except TBECH occurred in the sludge samples, and BDE-209 occurred in the highest concentrations followed by DBDPE.

In the previous Nordic screening study (Schlabach et al 2011), all the emerging BFRs were detected in sludge; PBDPE occurred in the highest concentrations. The concentrations in

sludge from the two Swedish WWTPs, Henriksdal and Käppala were in the same level or lower compared to WWTPs Ryaverken and Gässlösa in the present screening.

The results from the measurements in storm water and water and sludge from WWTPs indicate that these may be pathways for BFRs to the environment.

## 5.1.4 Occurrence of BFRs in the environment

### 5.1.4.1 Air

The air concentrations of the BFRs are given in **Table 15**.

Several of the emerging BFRs were detected in urban air in the same levels or somewhat lower than BDE-47, -100 and -99.

TBECH was found in urban air where the concentrations varied between 0.2 and 0.6  $\text{pg}/\text{m}^3$ . DBDPE was not detected in any of the air samples, but the LOQs (<1 and 2.5  $\text{pg}/\text{m}^3$ ) were higher than the measured concentration for the other BFRs except BDE-209 which occurred in concentrations between 1.7 and 9.3  $\text{pg}/\text{m}^3$ .

The concentrations of BFRs in urban air samples (BDE-209 excluded) are shown in **Figure 7**, where also the distribution of the individual substances is illustrated. The sum of the detected BFRs varied between 1 and 2.5  $\text{pg}/\text{m}^3$  and the distribution were similar among the different occasions. However the samples represent monthly values and daily variations is not shown.

Of the emerging BFRs only HBB was detected in background air and then in the same levels as in urban air. It occurred both at the Swedish West coast and the remote area in Northern Finland, which shows the potential for atmospheric long range transport.

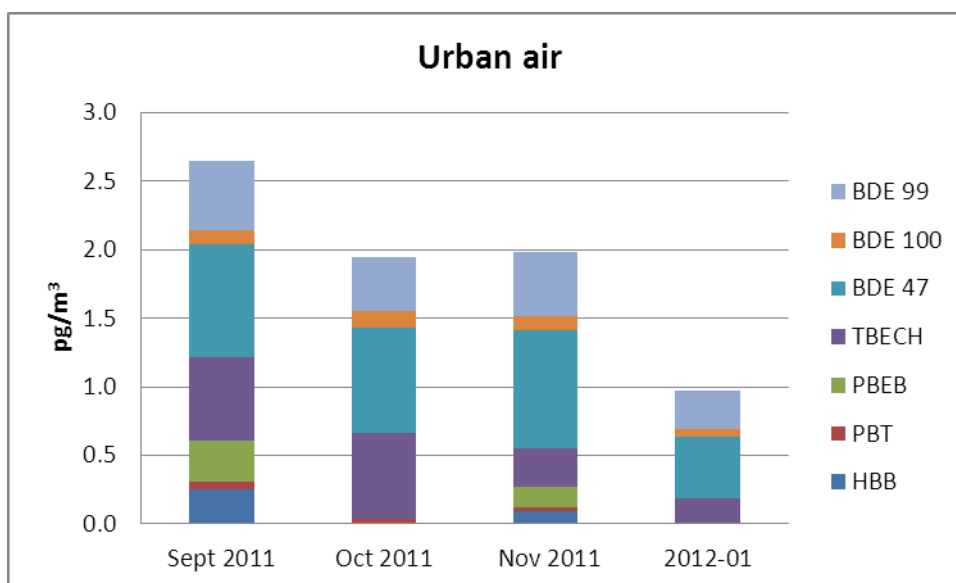
The concentrations of HBB in background air were in the same range as for the PBDEs except for BDE-209 which was higher. As in urban air there was a variation in the concentration of BDE-209 with occasionally increased concentrations. The levels of PBDEs at Råö and Pallas were normal during these sampling occasions when compared to data in the monitoring program ([www.ivl.se](http://www.ivl.se)). The LOQ for PBEB and DBDPE were higher compared to the concentrations of PBDEs.

No seasonal variation in the atmospheric concentration of the BFRs could be seen from these measurements.

DBDPE and BDE-209 have previously been measured in Swedish air by Egebäck et al. (2012) who found concentration of DBDPE and BDE-209 in the ranges 0.077-7.9  $\text{pg}/\text{m}^3$  and 0.093-1.8  $\text{pg}/\text{m}^3$  respectively. The highest concentrations were detected in air that originated from the European continent and the lowest concentrations during periods with rather stagnant air over southern Scandinavia.

**Table 15.** Atmospheric concentrations of BFRs.

	Unit	HBB	PBT	PBEB	DBDPE	TBECH	BDE-47	BDE-100	BDE-99	BDE-209
<b>Background air:</b>										
Råö, May 2011	pg/m <sup>3</sup>	0.21	<0.05	<0.2	<2.0	<0.01	0.084	0.014	0.052	0.52
Råö, Aug 2011	pg/m <sup>3</sup>	<0.16	<0.06	<0.3	<1.1	<0.01	0.13	<0.02	0.055	<2.4
Råö, Sep 2011	pg/m <sup>3</sup>	0.16	<0.03	<0.2	<1.1	<0.01	0.12	0.019	0.073	0.67
Råö, Nov 2011	pg/m <sup>3</sup>	0.16	<0.04	<0.2	<1.7	<0.01	0.079	<0.02	0.11	<0.3
Råö, Jan 2012	pg/m <sup>3</sup>	<0.16	<0.06	<0.2	<2.4	<0.01	0.13	0.029	0.13	9.3
Råö, Mar 2012	pg/m <sup>3</sup>	<0.08	<0.03	<0.2	<1.2	<0.01	0.13	0.024	0.11	1.2
Pallas, Jul 2011	pg/m <sup>3</sup>	0.10	<0.03	<0.2	<1.1	<0.01	0.27	0.020	0.12	0.33
Pallas, Jan 2012	pg/m <sup>3</sup>	<0.06	<0.02	<0.2	<0.99	<0.01	0.12	0.044	0.28	0.69
<b>Urban air:</b>										
Göteborg, Sep 2011	pg/m <sup>3</sup>	0.25	0.06	0.30	<1.6	0.61	0.82	0.10	0.51	9.2
Göteborg, Oct 2011	pg/m <sup>3</sup>	<0.1	0.04	<0.17	<1.5	0.62	0.77	0.12	0.39	2.3
Göteborg, Nov 2011	pg/m <sup>3</sup>	0.090	0.031	0.15	<1.1	0.28	0.86	0.10	0.47	4.5
Göteborg, Jan 2012	pg/m <sup>3</sup>	<0.09	<0.03	<0.16	<1.4	0.19	0.44	0.062	0.27	1.7



**Figure 7.** Atmospheric concentrations of BFRs in urban air, Göteborg (BDE-209 excluded).

#### 5.1.4.2 Deposition

None of the emerging BFRs were detected in the atmospheric deposition samples from Råö, while the PBDEs occurred in all deposition samples. The LOQs are given in Table 16. The detection limits for several of the BFRs were however higher compared to the measured deposition of PBDEs. The highest deposition fluxes occurred for BDE-209.

**Table 16.** BFRs in atmospheric deposition at the background site Råö.

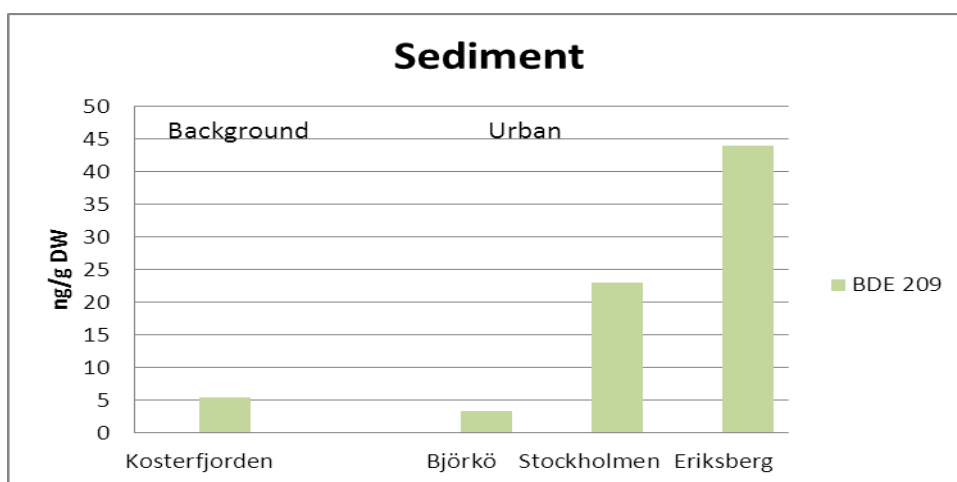
	Unit	HBB	PBT	PBEb	DBDPE	TBECH	BDE-47	BDE-100	BDE-99	BDE-209
Råö, May 2011	ng/m <sup>2</sup> day	<0.38	<0.025	<0.25	<2.5	<0.06	0.035	0.008	0.038	1.0
Råö, Aug 2011	ng/m <sup>2</sup> day	<0.38	<0.025	<0.25	<2.5	<0.06	0.040	0.007	0.035	0.61
Råö, Sep 2011	ng/m <sup>2</sup> day	<0.38	<0.025	<0.25	<2.5	<0.06	0.034	0.008	0.046	0.76
Råö, Nov 2011	ng/m <sup>2</sup> day	<0.19	<0.013	<0.13	<2.5	<0.06	0.025	<0.006	0.036	intef.
Råö, Jan 2012	ng/m <sup>2</sup> day	<0.38	<0.025	<0.25	<2.5	<0.06	0.14	0.030	0.14	0.50
Råö, Mar 2012	ng/m <sup>2</sup> day	<0.3	<0.05	<0.13	<2.5	<0.04	0.044	0.011	0.043	0.52

### 5.1.4.3 Sediment

The emerging BFRs were only detected in the sediment sample from Eriksberg, where it occurred in the same level as the penta BDEs, see **Table 17**. BDE-209 was found in all sediment samples with lowest concentrations at background sites (Kosterfjorden and Björkö) and the highest concentration in the sediment from Eriksberg, which is a former industrial area in Göteborg. A decreasing concentration gradient from Eriksberg to Björkö (located outside Göta älv) was found (**Figure 8**).

**Table 17.** Concentrations of BFRs in sediments from background (Kosterfjorden) and Göta älv estuary Björkö, Stockholmen and Eriksberg

	Unit	HBB	PBT	PBEb	DBDPE	TBECH	BDE-47	BDE-100	BDE-99	BDE-209
Kosterfjorden	ng/g DW	<0.55	<0.05	<0.35	<5	<0.13	<0.05	<0.05	<0.05	5.5
Björkö reference	ng/g DW	<0.27	<0.02	<0.17	<2.4	<0.06	<0.024	<0.024	<0.024	3.4
Stockholmen	ng/g DW	<0.32	<0.03	<0.21	<2.9	<0.07	<0.029	<0.029	<0.029	23
Eriksberg	ng/g DW	0.52	0.020	0.19	<1.5	<0.04	0.16	0.070	0.22	44



**Figure 8.** Concentrations of BDE-209 in sediment.

### 5.1.4.4 Biota

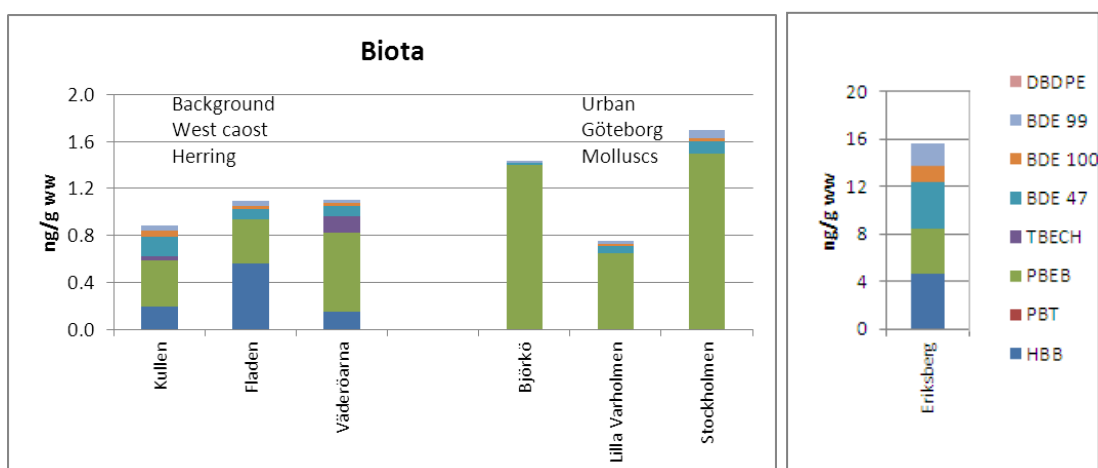
The concentrations of the BFRs in biota are given in **Table 18**.

HBB, PBEB and TBECH occurred in herring collected at background sites at the Swedish West coast. The concentrations were similar to the PBDEs, except BDE-209 which occurred in higher concentrations.

PBEB, BDE-47, BDE-100 and DBE-99 were detected in the molluscs collected in Göta älv estuary. The highest concentration occurred, as was the case for the sediments, in the sample collected outside Eriksberg, where also HBB was detected. The distribution of the BFRs differed between the various species as well as among the different sampling sites, which is shown in **Figure 9**.

**Table 18.** Concentrations of BRFs in biota

	Unit	Specie	HBB	PBT	PBEB	DBDPE	TBECH	BDE-47	BDE-100	BDE-99	BDE-209
<b>Background:</b>											
Kullen	ng/g ww	Herring	0.19	<0.04	0.4	<0.9	0.03	0.17	0.051	0.048	17
Fladen	ng/g ww	Herring	0.56	<0.04	0.38	<0.9	<0.04	0.081	0.029	0.042	2.1
Väderöarna	ng/g ww	Herring	0.15	<0.05	0.67	<0.9	0.14	0.093	0.028	0.021	0.53
<b>Urban:</b>											
Björkö reference	ng/g ww	Netted dogwhelk	<0.08	<0.08	1.4	<1.5	<0.08	0.022	<0.015	0.017	<0.77
Lilla Varholmen	ng/g ww	Netted dogwhelk	<0.09	<0.09	0.65	<1.9	<0.09	0.057	0.02	0.031	<0.59
Stockholmen	ng/g ww	Netted dogwhelk	<0.09	<0.09	1.5	<1.7	<0.09	0.099	0.032	0.067	<0.86
Eriksberg	ng/g ww	Netted dogwhelk	4.6	<0.08	3.9	<1.7	<0.08	3.9	1.3	1.9	<0.83



**Figure 9.** Concentrations of BFRs in herring and molluscs. The concentrations in the molluscs from Eriksberg are presented in different scale.

### 5.1.5 Human exposure

In human blood sera from 15 individuals HBB, PBT, PBEB, TBECH (<0.025 ng/g) or DBDPE (<2.5 ng/g) was not found. PBEB was found in one sample (0.072 ng/g), BDE-209 was found in five samples (0.027 – 0.14 ng/g, median for all samples <0.01 ng/g) while BDE-47, -100, -99, -154, -153 or -183 was not found (<0.01 - <0.04 ng/g).

In a recent study (Lignell et al 2013) PBDE concentrations were measured in blood serum from first-time mothers. Sampling was done in 2010 and the number of samples was 30. The LOQs were 0.00125 – 0.0098 ng/g fresh weight (not specified per analyte). This is from equal to the present investigation to 30 times lower. Despite generally lower LOQs than in the present study the detection frequency for BDE-47, 99, 100, 154 and 183 in blood sera from the first-time mothers were only 13%, 0%, 13%, 3% and 0% respectively. The concentrations found are given on lipid weight basis. With a typical value for lipid content assumed the maximum concentrations found were in the same range as the LOQs in the present study.

## 5.2 PBDFs

### 5.2.1 Sources and diffuse emissions indoor

Plastics from a recycling plant was found to contain high levels of PBDD/Fs (Figure 10 a and b). The total concentration was 2.6 µg/g in the plastic fraction that was supposed to contain BFR treated material. The concentration was lower in the waste fraction that was supposed to be free of BFR treated materials, but it still contained 0.43 µg/g PBDD/Fs. HeptaBDF dominated in the BFR fraction and octaBDF in the non-BFR fraction.

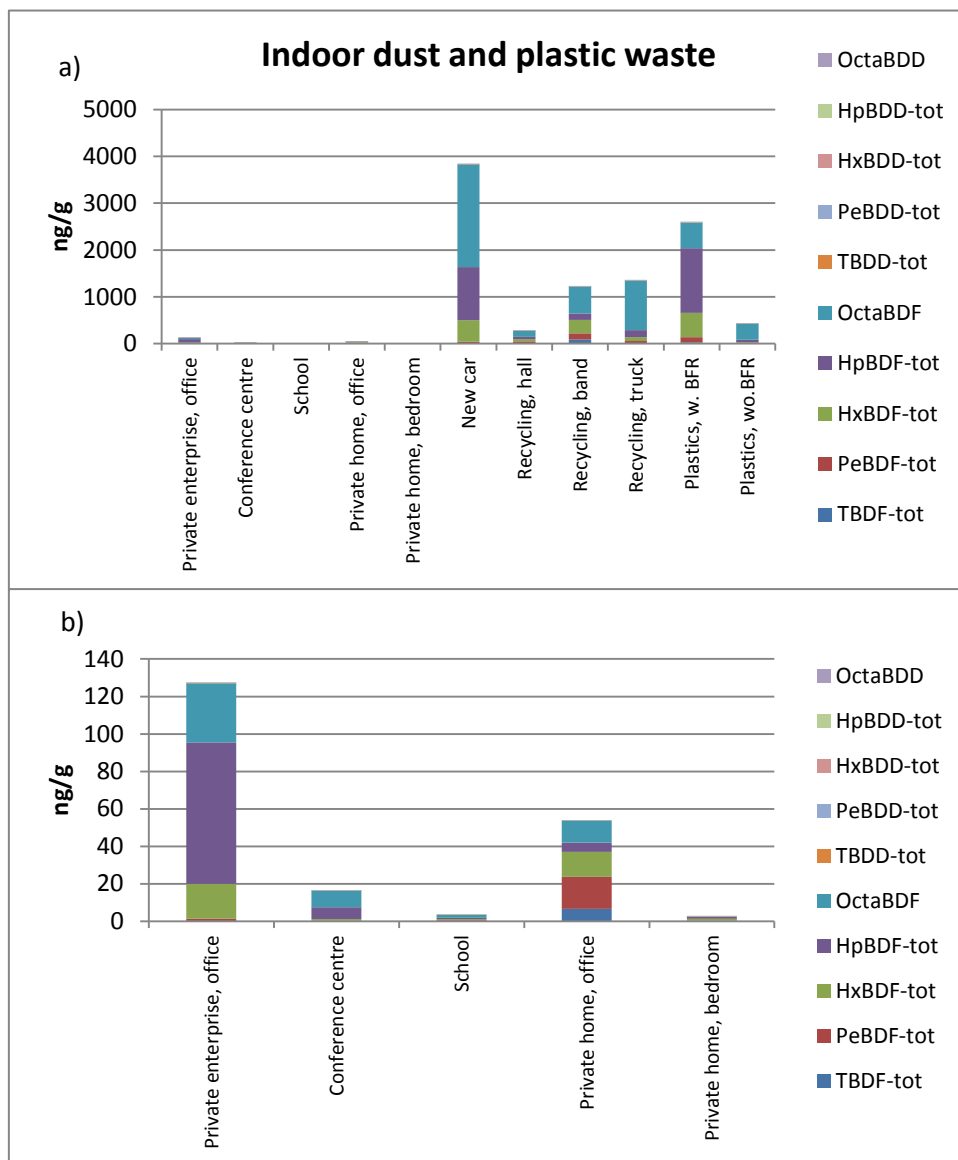
High levels (0.28 – 1.3 µg/g) of PBDD/Fs were also detected in dust collected at the recycling facility. The homologue profile were dominated by octaBDF, but hexa- and heptaBDFs were also present, i.e. the profile were somewhere in between the two plastics samples.

Dust collected from a new car contained much higher levels of PBDD/Fs (3.8 µg/g) than the other indoor environments. It was even higher than the BFR containing plastics (2.6 µg/g).

Dust from the office environments contained about an order of magnitude higher concentrations than dust from a conference center, a school and a bedroom. Generally, the highly brominated homologues dominated, but PeBDFs accounted for the largest share of the PBDD/Fs found in dust from the home office.

The levels of the most toxic congeners, i.e. 2,3,7,8- substituted TeBDD/Fs and PeBDD/Fs, were highest in dust samples from the recycling facility, followed by dust from the new car, and dust from the home office.

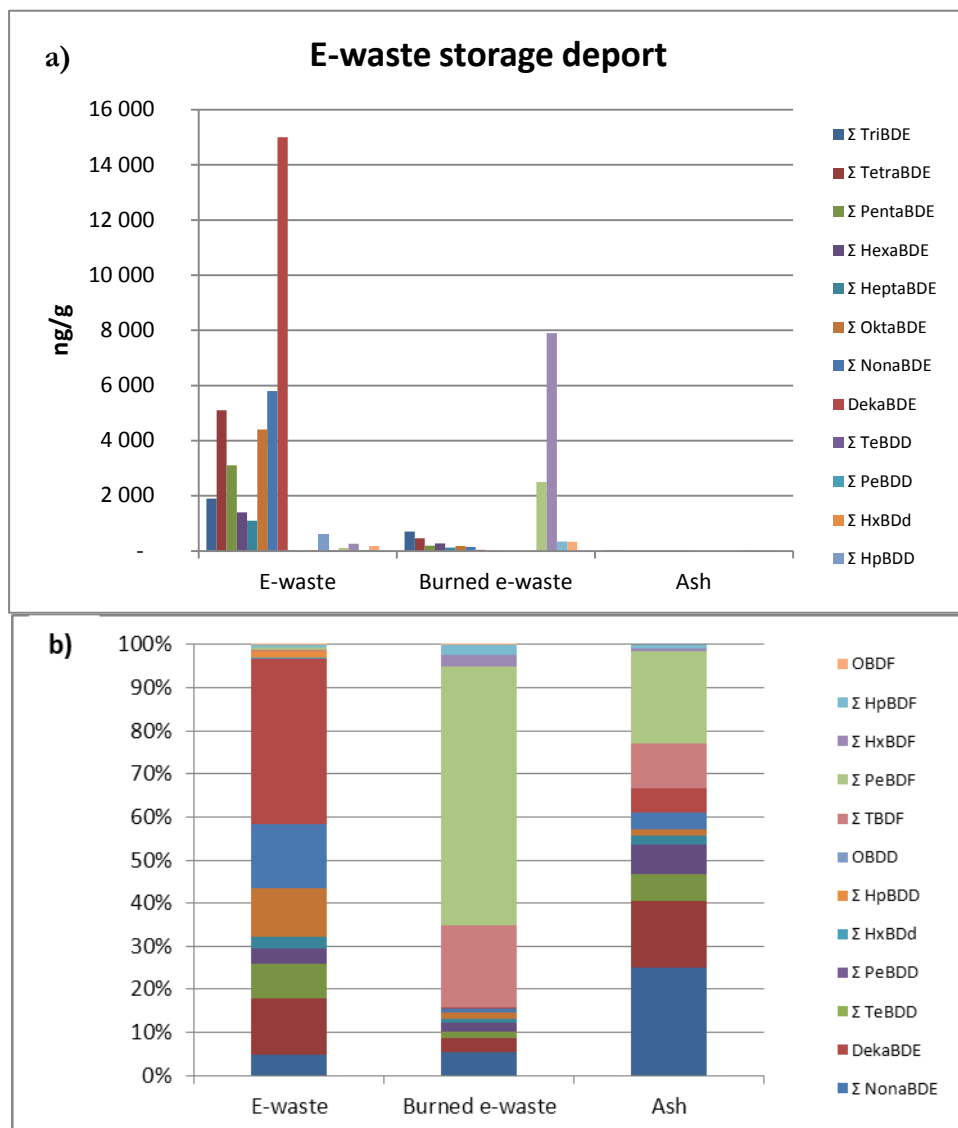
The proportion of PBDD/Fs to deca-BDE was similar (range 0.34% - 5.6%) in all dust samples except the conference center and the new car. It was also similar to the plastic waste samples (0.44% and 5.1%). The samples from the conference center and new car contained a lower proportion (0.002% and 0.010%, respectively) of PBDD/Fs. This may indicate different dominant sources of pollution, for example, BFR treated textiles (conference center and new car) and BFR containing plastic materials (all other samples).



**Figure 10a-b.** a) Concentrations of PBDD/Fs (ng/g) in dust and plastic waste fractions with and without brominated flame retardants (BFRs). b) Concentrations of PBDD/Fs (ng/g) in dust from public and private indoor environment. This graph was magnified to enhance the visibility in the low concentration range.



Electronic waste (e-waste) from a waste storage depot were also sampled following a fire. Samples of unaffected waste, burned waste and ash were analysed separately and it was clear that dehalogenation took place; the average degree of halogenation of both PBDD/Fs and PBDEs decreased in the order e-waste > burned e-waste > ash (Figure 11). It was also clear that PBDEs were converted to PBDFs, in particular to tetra- and pentaBDFs.

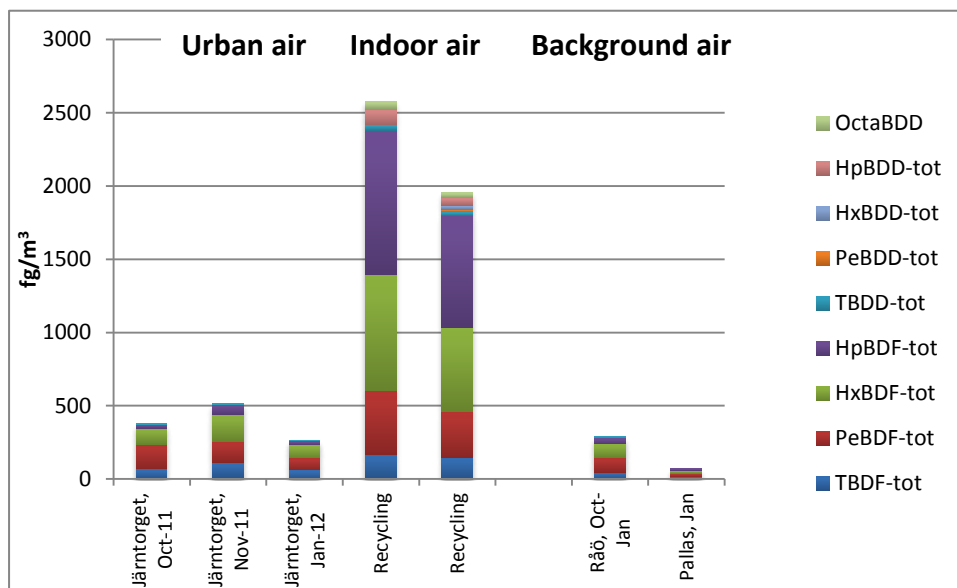


**Figure 11a-b.** a) Concentrations of PBDEs and PBDDs (sum TeBDD and sum PeBDD) and b) distribution of PBDD/Fs (ng/g) in samples collected from an e-waste storage depot following an accidental fire.

### 5.2.2 Pathways in an urban area

Urban air in Göteborg (**Figure 12**) contained similar levels of PBDD/Fs as the west coast background location (Rådö) but higher concentrations than found in remote air from Northern Finland (Pallas). The levels were, however, much lower than in indoor air from a plastics recycling facility.

The homologue pattern was very similar for the outdoor air samples, and this pattern was distinctly different from the air from the recycling facility. This may indicate that the pollutants stem from diffuse sources, possibly long-range air transport. It may also suggest that highly brominated congeners are dehalogenated in ambient air. However, the limit number of data do not allow any firm conclusions to be drawn.



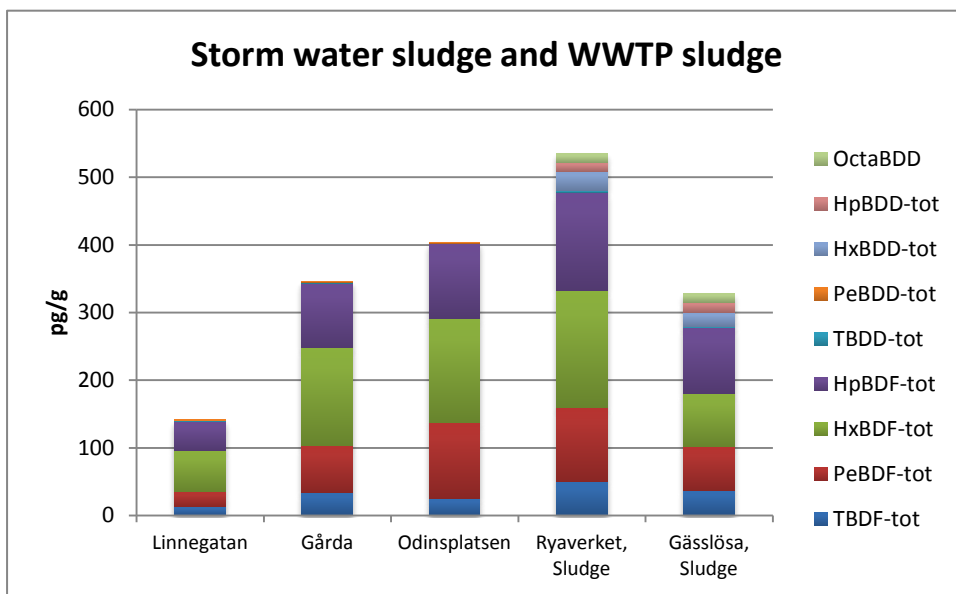
**Figure 12.** Concentrations of PBDD/Fs ( $\text{fg}/\text{m}^3$ ) in urban air (Järntorget), at a recycling facility (indoor industrial air) and background air (Råö and Pallas).

Storm water sludge from Göteborg had a similar congener profile as its urban air (Figure 13 and Figure 12). Sewage sludge from Ryaverket WWTP in the same city contained higher amounts (on dry matter basis) and exhibited a different profile; with more PBDDs. This suggests that there are also other sources of PBDD/Fs besides storm water, i.e. sanitary, commercial, industrial wastewaters.

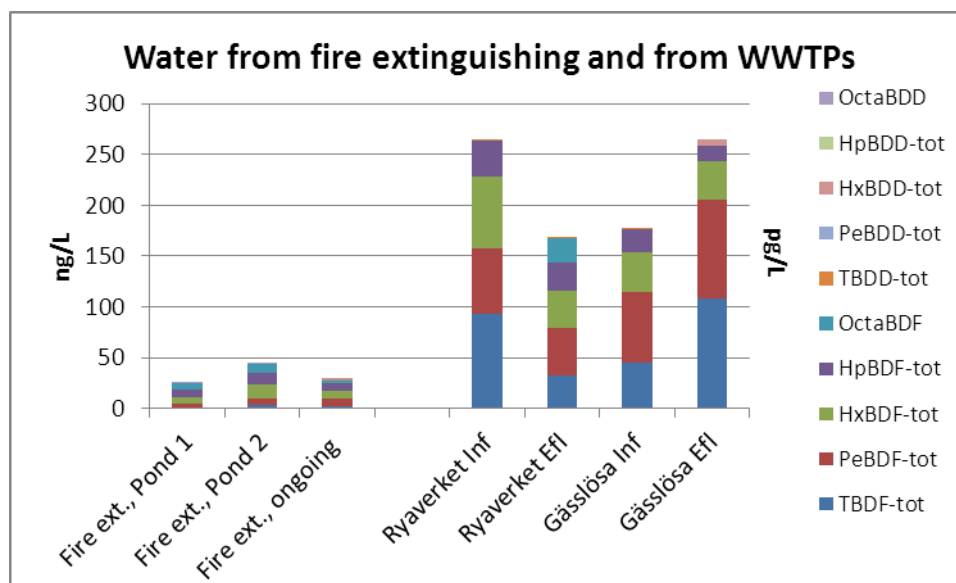
Sludge from Gässlösa WWTP had a similar profile as sludge from Ryaverket, but with lower concentrations. This indicates that the industrial activities in the Borås area (plastic and textile industries) has a limited impact on the sludge levels.

The STP process reduced the levels of PBDD/Fs (Figure 14), although less than expected for lipophilic persistent organic pollutants (POPs), which usually are reduced by ca. 90% (Olofsson, 2012).

Finally, fire extinguishing water was found to contain 2 orders of magnitude higher PBDD/F concentrations than effluent water. If such waters are not properly collected it may result in considerable environmental emissions, at least on a local scale.



**Figure 13.** PBDD/F concentrations (pg/g) in Göteborg storm water sludge (normalized to particulate matter) and sewage sludge from Ryaverket, Göteborg and Gässlösa, Borås (normalized to dry weight).



**Figure 14.** Concentrations of PBDD/Fs in fire extinguishing water (ng/L) and in sewage influent and effluent (pg/L) from Ryaverket, Göteborg and Gässlösa, Borås. Note the different scales!

## 5.2.3 Occurrence in the environment

### 5.2.3.1 Air

There seems to be a seasonal trend in PBDD/F air concentrations at Råö on the Swedish west coast, with higher concentrations in winter time and lower in summer (Figure 15). A similar trend was observed for PCDD/Fs (Appendix 5).

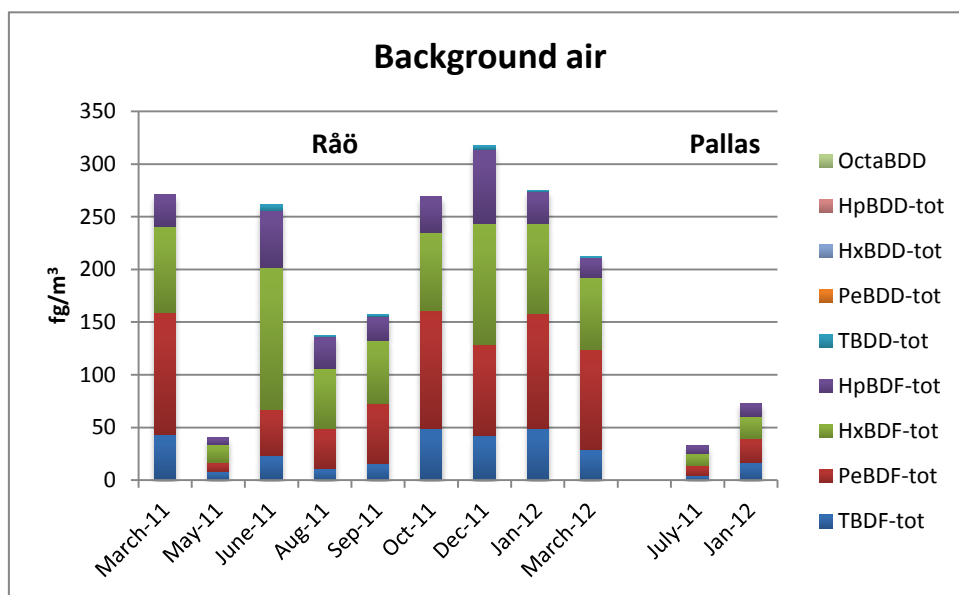


Figure 15. Concentrations of PBDD/Fs (fg/m<sup>3</sup>) in air from Råö on the Swedish West coast. June and December samples are averages of the short time samples.

However, the June levels clearly deviated from this trend. During this period there were a large number of extensive forest fires in Southern Russia and Ukraine and smoke occasionally reached Scandinavia (IT news; 2011-05-23). This may have contributed to the PBDD/F levels detected, either directly (formation during fires) or indirectly (evaporation of PBDD/Fs absorbed in the lipid surface layers of vegetation).

The short time measurements support such a hypothesis (Figure 16). There is a large variation in levels between time periods and the sampled air (packages) that contain the highest levels all originate from South or East, which support it. One of the low level air samples originate from East, but this passed northern Russia and Finland and may not have been affected by the smoke.

The December short term sampling campaign indicate that air originating from North or Northwest (passing Greenland and Norway) contain lower levels than air from West (passing UK and Ireland)(Figure 16).

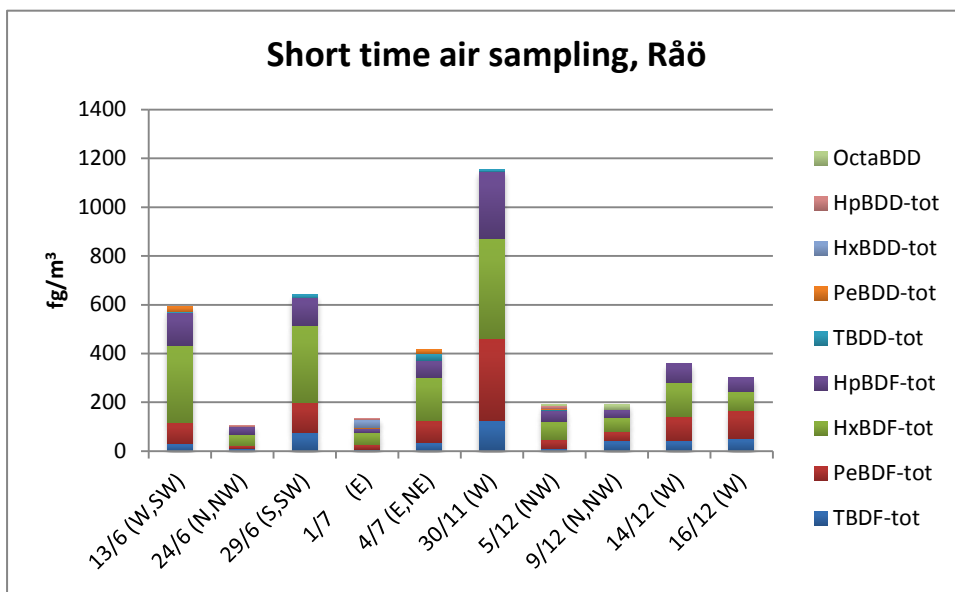


Figure 16. Concentrations of PBDD/Fs ( $\text{fg}/\text{m}^3$ ) in air from Råö on the Swedish West coast.

### 5.2.3.2 Deposition

The deposition show a similar time trend, with the exception of the March-2011 data that were significantly lower than the March-2012 values (Figure 17). It also included a concentration peak during the late spring of 2012, as did the air samples.

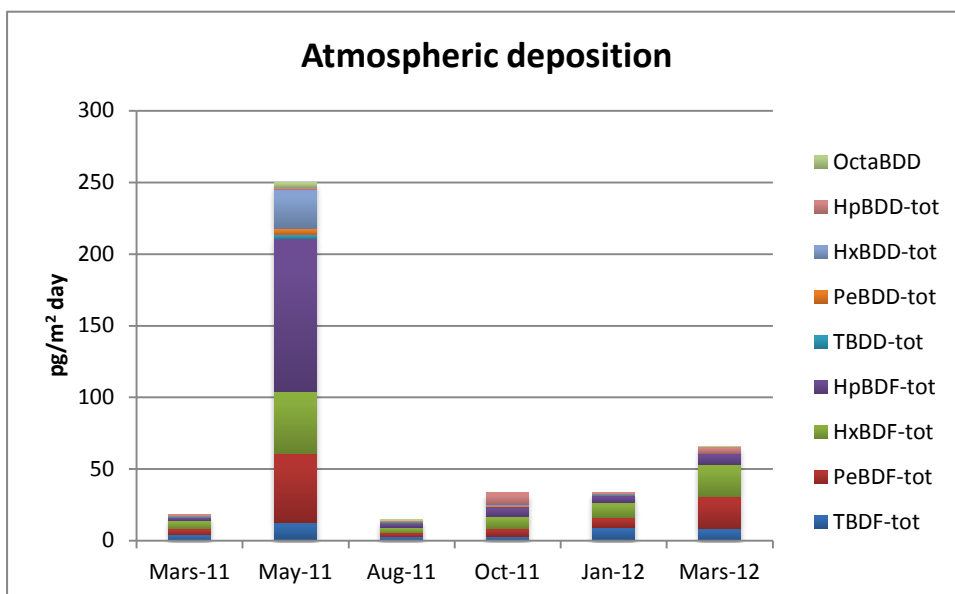


Figure 17. Atmospheric deposition of PBDD/Fs ( $\text{pg}/\text{m}^2$ ) at Råö on the Swedish West coast.

## **5.2.4 Human exposure**

The human milk did not contain any detectable quantities of PBDD/Fs (limits of detection 0.02, 0.04 and 0.2 pg/g fresh weight for tetra-hexaBDD/Fs, heptaBDD/Fs and octaBDD/Fs, respectively).

These results were unexpected given that PBDFs were previously detected in human milk (see introduction). A thorough investigation of the current and previous data revealed that nona-BDEs (formed by debromination of decaBDE) were not efficiently discriminated, chromatographically and mass spectrometrically, from the heptaBDFs in the previous study. Thus, the previously detected heptaBDFs appears to be analytical artefacts from nona-BDEs.

PCDD/Fs were detected in all samples (range 0.12 to 0.30 pg TEQ/g fresh weight).

# **6 Summary and conclusions**

## **6.1 Sources and pathways**

The emerging BFRs, PBDEs and PBDFs occurred in “high” concentrations in air and dust from a recycling industry for electronic waste. The occurrence of BFRs at this in electronic waste facility shows that electronic articles contain these chemicals. BDE-209 and DBDPE were found in highest concentrations. DBDPE has similar applications as BDE-209 and it has been marketed as a general substitute for this substance. The occurrence of PBDFs may indicate that the BFRs are contaminated or that PBDEs are transformed to PBDFs in the recycling processes.

The presence of both the emerging BFRs and PBDEs in dust collected in a “new private car” shows that these flame retardants are used in textiles and plastic details in newly manufactured cars. DBDPE and BDE-209 which are used as flame retardants in textiles occurred in high concentration. The simultaneous occurrence of high levels of PBDFs indicates presence in BFR formulations.

The occurrences of the included BFRs in dust from different indoor environments, both public and private spaces, indicates a wide application of these chemicals in articles and household products and that diffuse emissions of BFRs from consumer products may take place in the indoor environment. The differences in the distribution among the BFRs for the different dust samples indicate that the BFRs may originate from different consumer product and articles.

Higher ratios of PBDFs vs. BDE-209 were found in dust from environments that are likely to contain BFR containing plastics (offices and recycling facilities) than in dust from environments containing BFR treated textile products (car and conference center interiors).

This may indicate that PBDFs are formed during production or use of flame retarded plastics.

The emissions of BFRs and PBDFs will take place both to air and water. BFRs and PBDFs emitted indoors to air and to settled dust may via ventilation be transported to outdoor air. The presence of these pollutants in influent, effluent and sludge from municipal WWTPs also indicate that diffusive emissions from household products occur and that these chemicals may be emitted to the environment from WWTPs. The occurrence of the BFRs and PBDD/Fs in storm water and fire extinguishing water shows that these may also be pathways to the environment.

Thus, the emerging BFRs and PBDFs were generally found in samples from WWTPs, storm water, indoor air and dust, indicating that they may be emitted and transported to the environment via these sources and pathways.

## 6.2 Environmental occurrence

Several of the emerging BFRs occurred in all the included environmental matrices except in atmospheric deposition. The concentrations in samples at urban sites were higher compared to background samples.

Most of the emerging BFRs were detected in urban air, in the same levels or somewhat lower than BDE-47, -100 and -99. BDE-209 occurred in the highest concentrations. One of the emerging BFRs, HBB, was detected in background air, in the same concentration range as the PBDEs. It was found both at the Swedish West coast and in the remote area in Northern Finland, which shows the potential for atmospheric long range transport of HBB.

PBDD/Fs were found in all air and deposition samples from the background areas and the importance of atmospheric long range transport to Sweden was confirmed. There appears to be an annual variation in both PBDD/F and PCDD/F concentrations, with higher levels during winter. Significantly elevated levels were detected in May-June 2011, which coincided with extensive forest fires in southern Russia and Ukraine.

In sediments, the emerging BFRs were only detected in a sample from Göta Älv near a former industrial site where they occurred in the same concentration level as the penta-BDEs.

The occurrence of emerging BFRs in biota from background sites shows that these chemicals like the PBDEs are further spread to the ecosystem. The distribution of the BFRs differed between the various species as well as among the different sampling sites.

The only emerging BFR detected in human sera was PBEB, which occurred in one out of 15 samples. PCDD/Fs were found in all human milk samples, but no PBDD/Fs were detected.

## 6.3 Summary and future studies

In this screening several possible sources and pathways for the emerging BFRs (HBB, PBT, PBEB, DBDPE, TEBCH) were identified and the results showed that these substances, which are substitutes for the PBDEs, are widely spread in Sweden. Diffusive emissions of the BFRs from consumer products and articles as well as from e.g. recycling industries may take place and these chemicals are further spread to the environment via WWTPs, storm water, indoor air and dust.

Electronics and car interiors appears to be major reservoirs and sources of PBDFs. Very high levels of highly brominated PBDFs were found in e-waste plastics ( $>1 \mu\text{g/g}$ ). Flame retarded plastics may therefore constitute a major stock of PBDFs in society, carrying 1g of PBDFs per ton of plastic. The resulting levels in office dust were also significant (ca 100 ng/g dust).

Atmospheric transport and deposition could also be an important pathway for BFRs to the Swedish environment and for their occurrence in remote areas e.g. the Arctic. HBB was found both at the Swedish West coast and in the remote area in Northern Finland, in the same levels as the PBDEs which shows potential for atmospheric long range transport. PBT and TEBCH were not found at remote areas (LOQs were lower than for HBB). For PBEB and DBDPE LOQs were higher than the PBDE concentration range, thus it was not possible to evaluate the importance of the atmospheric transport.

The presence of BFRs in the indoor environment and in biota, from urban and background sites indicates that both humans and the ecosystem are exposed to the emerging BFRs. Serum was selected as matrix to study possible human exposure. The BFRs were not detected which could be due to high LOQs.

Based on the results from the current screening we propose a follow-up study:

In order to identify the importance of the atmospheric transport new measurements of emerging BFRs in air should be carried out e.g. at the Swedish west coast and in northern Finland.

The serum samples should be re-analysed using another more sensitive analytical method.

A number of other emerging BFRs (e.g. selection based on the EFSA report and/or the previous Nordic screening) could be included.

Finally, additional studies of house dust and e-waste would be important to quantify the human exposure and stock of BFRs and BFR impurities (e.g. PBDFs) in society.



## **7 Acknowledgement**

The staff at the municipal sewage treatment plants in Göteborg and Borås, the City of Göteborg “Park and Nature Management” and the recycling industry are acknowledged for their help during sampling.

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## 8 References

- Arnoldsson K., Andersson P., Haglund P. Formation of environmentally relevant brominated dioxins from 2,4,6-tribromophenol via bromoperoxidase-catalyzed dimerization. *Environmental Science and Technology*, 46(2012a), 7239-7244.
- Arnoldsson K., Andersson P., Haglund P. Photochemical formation of polybrominated dibenzo-p-dioxins (PBDDs) from environmentally abundant hydroxylated polybrominated diphenyl ethers (OH-PBDEs). *Environmental Science and Technology*, 46(2012b), 7567-7574.
- Bergman Å., Rydén A., Law R. J., de Boer J., Covaci A., Alae M., Birnbaum L., Petreas M., Rose M., Sakai S., van den Eede N. and van der Veen I., (2012): A novel abbreviation standard for organobromine, organochlorine and organophosphorus flame retardants and some characteristics of the chemicals. *Environment International* 49 (2012) 57-82.
- Birnbaum, L.S. Staskal D.F., Diliberto J.J. (2003): Health effects of polybrominated dibenzo-p-dioxins (PBDDs) and dibenzofurans (PBDFs). *Environment International* 29 (2003) 855– 860
- ChemIDPlus. <http://chem.sis.nlm.nih.gov/chemidplus/>
- EFSA Panel on Contaminants in the Food Chain (CONTAM); Scientific Opinion on Emerging and Novel Brominated Flame Retardants (BFRs) in Food. *EFSA Journal* 2012;10(10):2908. [125 pp.] doi:10.2903/j.efsa.2012.2908. Available online: [www.efsa.europa.eu/efsajournal](http://www.efsa.europa.eu/efsajournal)
- ESIS - European chemical Substances Information System (2012). Joint Research Centre, <http://esis.jrc.ec.europa.eu/>
- Haglund P, Malmvärn A, Bergek S, Bignert A, Kautsky L, Nakano T, Wiberg K, Asplund L. (2007): Brominated dibenzo-p-dioxins - A new class of marine biotoxins? *Environmental Science and Technology*, 41, 3069-3074, 2007
- Harju, M., Heimstad, E., Herzke, D., Sandanger, T., Posenr, S. and Wania, F., (2008): Current state of knowledge and monitoring requirements – Emerging “new” brominated flame retardants in flame retarded products and the environment. TA-2462/2008.
- Harrad S., Ibarra C., Abdallah M. A., Boon R., Neels H., Covaci A., (2008): Concentrations of brominated flame retardants in dust from United Kingdom cars, homes, and offices: Causes of variability and implications for human exposure, *Environment International*, 34, 1170–1175
- Hoh, E., L. Zhu and A. R. Hites (2005): "Novel Flame Retardants, 1,2-Bis(2,4,6-tribromophenoxy)ethane and 2,3,4,5,6-Pentabromoethylbenzene, in United States' Environmental Samples" *Environ. Sci. Technol.* 39(8): 2472-2477.
- Hovander L, Athanasiadou M, Asplund L, Jensen S, Wehler EK. (2000): “Extraction and cleanup methods for analysis of phenolic and neutral organohalogens in plasma”. *J Anal Toxicol.* 2000 24(8):696-703.

- KemI-Stat (2012): Swedish Chemicals Agency, <http://apps.kemi.se/kemistat/>
- Kierkegaard, A., C. A. d. Wit, L. Asplund, M. S. McLachlan, G. O. Thomas, A. J. Sweetman and K. C. Jones (2009). "A Mass Balance of Tri-Hexabrominated Diphenyl Ethers in Lactating Cows." *Environmental Science & Technology* 43(7 %R doi:10.1021/es803440a): 2602-2607.
- Lignell, Sanna; Aune, Marie; Glynn, Anders; Cantillana, Tatiana; Isaksson, Martin 2013 Polybrominated diphenylethers (PBDE) and hexabromocyclododecane (HBCD) in paired samples of blood serum and breast milk – a correlation study. Report to the Swedish EPA.  
[http://www.imm.ki.se/Datavard/Rapporter/Sakrapport\\_korrelationPBDE\\_slutlig.pdf](http://www.imm.ki.se/Datavard/Rapporter/Sakrapport_korrelationPBDE_slutlig.pdf)
- Møskeland, T. (2010). Environmental screening of selected “new” brominated flame retardants and selected polyfluorinated compounds 2009”. Klima- of Fo-rurensnings Direktoratet. TA-2625/2010. Oslo, Norway.
- OECD, (1995). Risk reduction monograph no.3: Selected brominated flame retardants Background and national experience with reducing risk. OECD Environment Monograph Series no. 102, Paris, France.
- Olofsson U., (2012): Removal processes in sewage treatment plants - Sludge quality and treatment efficiency of structurally diverse organic compounds. Umeå University, PhD thesis, 2012-02-10.
- OSPAR (Oslo-Paris Commission), 2011. OSPAR list of chemicals for priority action (revised 2011) (Reference number 2004-12). Available from [http://www.ospar.org/content/content.asp?menu=00940304440000\\_000000\\_000000](http://www.ospar.org/content/content.asp?menu=00940304440000_000000_000000)
- Schlabach, M., Remberger, M., Brorström-Lundén, E., Norström, K., Kaj, L., Andersson, , Herzke, D., Borgen, A., Harju, M. , Bouttrup, S., Dam, M., Mannio, J., Jörundsdóttir, H. Ó., Hedlund, B., (2011). ”Brominated Flame Retardants (BFR) in the Nordic Environment”. *NMR TemaNord* 2011:528.
- Tomy, G. T., K. Pleskach, G. Arsenault, D. Potter, R. McCrindle, C. H. Marvin, E. Sverko and S. Tittlemier (2008). "Identification of the Novel Cycloaliphatic Brominated Flame Retardant 1,2-Dibromo-4-(1,2-dibromoethyl)cyclohexane in Canadian Arctic Beluga (*Delphinapterus leucas*)." *Environmental Science & Technology* 42 (2 %R doi:10.1021/es072043m): 543-549.
- WHO/ICPS (1997). “Flame Retardants: A General Introduction”. *Environmental Health Criteria* 192, International Programme on Chemical Safety, <http://www.inchem.org/documents/ehc/ehc/ehc192.htm>.
- Xie Z., Möller A., Ahrens L., Sturm R. and Ebinghaus R., (2011). “Brominated Flame Retardants in Seawater and Atmosphere of the Atlantic and the Southern Ocean”. *Environ. Sci. Technol.* 2011, 45, 1820–1826

### Appendix 1 Dust sampling

Sample_id	Sample	Analysis of:	Dust, g	Sampling date	Duration of the sampling	Description of the sampling site	Dust was collected from surfaces such as:
1248	Private home, office	BFR	0.22	2011-11-22	10-15 min	Home office with 3 computers, printer and other electronic equipment, size: approximately 10 m <sup>2</sup>	Floor, furniture, desks with computers on it
3512:54		PBDF	0.32				
1249	Private home, bedroom	BFR	0.39	2011-11-22	10-15 min	Bedroom, no electronic equipment, bed, furniture and textiles, 2 small carpets, size: approximately 12 m <sup>2</sup>	Floor, carpets, strips, furniture, sides of the bed
3512:55		PBDF	0.36				
1247	School	BFR	0.46	2011-11-22	10-15 min	Classroom with tables, large carpet and a playroom with shelves, carpets, sofas, tables and computers, totally about 80 m <sup>2</sup>	Floor, carpets, strips, furniture, sofas, and around the computers
3512:53		PBDF	0.12				
1245	Private enterprise, office	BFR	0.25	2011-11-30	15-20 min	Office with computers and furniture	Floor, strips, furniture and around the computers and printer
3512:51		PBDF	0.25				
-	Disassembly hall	BFR	0.63	2011-12-13	5 min	Large warehouse space for storage, dismantling and sorting of waste. A lot of dust on all surfaces. The floor is cleaned twice a week	Strips and shelves
3512:59		PBDF	2.7				
1252	Conveyor belt	BFR	0.59	2011-12-13	10 min	Conveyor belt used for dismantling and sorting of the waste	Conveyor belt and around this
3512:60		PBDF	0.74				
1253	Recycling ind., electronic waste, truck	BFR	1.9	2011-12-13	15 min	Truck used for transporting the waste between storage area and conveyor belt	Inside the truck, seat, strips and dashboard
3512:61		PBDF	0.36				
1250	New car	BFR	0.017	2012-01-25	15 min	New car, used for approximately 1 week	Inside the car, floor, roof, seats and dashboard
3512:56		PBDF	0.017				
1246	Conference centre	BFR	0.49	2012-02-08	15 min	Conference centre	Furniture, strips, walls
3512:52		PBDF	0.69				

## Appendix 2 Sample list

Lab-ID IVL	Lab-ID Umeå	Sample type	Site/Characteristics	Matrix	Start date	Stop date	X-coordinates	Y-coordinates	Specie
-	3512:13	Background	Råö	Air	2011-06-13	2011-06-15	6369857	1266139	
-	3512:18	Background	Råö	Air	2011-06-24	2011-06-27	6369857	1266139	
-	3512:20	Background	Råö	Air	2011-06-29	2011-07-01	6369857	1266139	
-	3512:21	Background	Råö	Air	2011-07-01	2011-07-04	6369857	1266139	
-	3512:22	Background	Råö	Air	2011-07-04	2011-07-06	6369857	1266139	
-	3512:24	Background	Råö	Air	2011-11-30	2011-12-02	6369857	1266139	
-	3512:26	Background	Råö	Air	2011-12-05	2011-12-07	6369857	1266139	
-	3512:28	Background	Råö	Air	2011-12-09	2011-12-12	6369857	1266139	
-	3512:30	Background	Råö	Air	2011-12-14	2011-12-16	6369857	1266139	
-	3512:31	Background	Råö	Air	2011-12-16	2011-12-19	6369857	1266139	
1286	3512:39	Background	Pallas	Air	2011-06-27	2011-08-01	7564800	1847100	
1287	3512:40	Background	Pallas	Air	2012-01-02	2012-01-30	7564800	1847100	
-	3512:33	Background	Råö	Air	2011-02-28	2011-03-28	6369857	1266139	
1288	3512:34	Background	Råö	Air	2011-05-02	2011-05-30	6369857	1266139	
1289	3512:35	Background	Råö	Air	2011-08-01	2011-08-29	6369857	1266139	
1290	3512:36	Background	Råö	Air	2011-08-29	2011-09-26	6369857	1266139	
1291	-	Background	Råö	Air	2011-10-31	2011-10-28	6369857	1266139	
1292	3512:37	Background	Råö	Air	2012-01-02	2012-01-30	6369857	1266139	
1293	3512:38	Background	Råö	Air	2012-02-27	2012-04-02	6369857	1266139	
1298	3512:41	Diffuse	Järntorget, Göteborg	Air	2011-08-29	2011-10-03	6403883	1270388	
1295	3512:42	Diffuse	Järntorget, Göteborg	Air	2011-09-29	2011-10-31	6403883	1270388	
1296	3512:43	Diffuse	Järntorget, Göteborg	Air	2011-10-31	2011-11-28	6403883	1270388	
1297	3512:44	Diffuse	Järntorget, Göteborg	Air	2012-01-02	2012-01-30	6403883	1270388	
-	3512:45	Background	Råö	Atm. dep	2011-02-28	2011-03-28	6369857	1266139	
1299	3512:46	Background	Råö	Atm. dep	2011-05-02	2011-05-30	6369857	1266139	
1300	3512:47	Background	Råö	Atm. dep	2011-08-01	2011-08-29	6369857	1266139	
1301	3512:48	Background	Råö	Atm. dep	2011-08-29	2011-09-26	6369857	1266139	
1302	-	Background	Råö	Atm. dep	2011-10-31	2011-10-28	6369857	1266139	
1303	3512:49	Background	Råö	Atm. dep	2012-01-02	2012-01-30	6369857	1266139	
1304	3512:50	Background	Råö	Atm. dep	2012-02-27	2012-04-02	6369857	1266139	
9593	-	Background	Kosterfjorden, Strömstad	Sediment			6531904	275817	
1109	-	Background	Kullen	Biota			6249400	1288200	Herring, muscle
1110	-	Background	Fladen	Biota			6351324	1259832	Herring, muscle
1111	-	Background	Väderöarna	Biota			6498520	1214286	Herring, muscle
9602	-	Diffuse	Björkö, Göteborg	Sediment	2011-10-20		6407416	1254886	
9601	-	Diffuse	Stockholmen, Göteborg	Sediment	2011-10-17		6401297	1262613	

Lab-ID IVL	Lab-ID Umeå	Sample type	Site/Characteristics	Matrix	Start date	Stop date	X-coordinates	Y-coordinates	Specie
9615	-	Diffuse	Eriksberg, Göteborg	Sediment	2011-10-17		6403799	1268142	
9616	-	Diffuse	Björkö, Göteborg	Biota	2011-10-20		6407416	1254886	Netted dogwhelk
9617	-	Diffuse	Stockholmen, Göteborg	Biota	2011-10-17		6401297	1262613	Netted dogwhelk
9618	-	Diffuse	Eriksberg, Göteborg	Biota	2011-10-17		6403799	1268142	Netted dogwhelk
9619	-	Diffuse	Lilla Varholmen, Göteborg	Biota	2011-10-20		6404791	1255420	Netted dogwhelk
9607	-	Diffuse	Linnégatan, Göteborg	Stormwater	2011-10-19		6403066	1270296	
9608	3512:4	Diffuse	Gårda, Göteborg	Stormwater	2011-10-19		6403744	1272826	
9609	3512:6	Diffuse	Odinsplatsen, Göteborg	Stormwater	2011-10-19		6404825	1272378	
-	3512:1	Diffuse	Linnégatan, Göteborg	Stormwater sludge	2011-10-19		6403066	1270296	
-	3512:3	Diffuse	Gårda, Göteborg	Stormwater sludge	2011-10-19		6403744	1272826	
-	3512:5	Diffuse	Odinsplatsen, Göteborg	Stormwater sludge	2011-10-19		6404825	1272378	
9610	3512:7	Diffuse	Ryaverket WWTP, Göteborg	Influent	2011-11-10		6403597	1266630	
9611	3512:8	Diffuse	Ryaverket WWTP, Göteborg	Effluent	2011-11-10		6403597	1266630	
9599	3512:9	Diffuse	Ryaverket WWTP, Göteborg	Sludge	2011-11-10		6403597	1266630	
-	3512:10	Diffuse	Gässlösa WWTP, Borås	Influent	2011-11-16		6401371	1328659	
9613	3512:11	Diffuse	Gässlösa WWTP, Borås	Effluent	2011-11-16		6401371	1328659	
9600	3512:12	Diffuse	Gässlösa WWTP, Borås	Sludge	2011-11-16		6401371	1328659	
1245	3512:51	Indoor env.	Private enterprise, office	Dust	2011-11-30				
1246	3512:52	Indoor env.	Conference centre	Dust	2012-02-08				
1247	3512:53	Indoor env.	School	Dust	2011-11-22				
1248	3512:54	Indoor env.	Private home, office	Dust	2011-11-22				
1249	3512:55	Indoor env.	Private home, bedroom	Dust	2011-11-22				
9624	-	Point source	Pond 1, fire extinguishing water	Water	2011-06-24				
9625	-	Point source	Pond 2, fire extinguishing water	Water	2011-06-24				
9626	-	Point source	Ongoing fire-fighting	Water	2011-06-17				
1250	3512:56	Point source	New car	Dust	2012-01-25				
-	3512:63		Recycling ind, plastics (BFR fraction)	Plastic	2012-May				
-	3512:62		Recycling ind, plastics (ABS, HIPS, PP fraction)	Plastic	2012-May				
1306	3512:57	Point source	Recycling ind., electronic waste, disassembly hall	Indoor Air	2011-12-13	2011-12-19			
1307	3512:58	Point source	Recycling ind., electronic waste, disassembly hall	Indoor Air	2011-12-19	2011-12-27			
-	3512:59	Point source	Recycling ind., electronic waste, disassembly hall	Dust	2011-12-13				
1252	3512:60	Point source	Recycling ind., electronic waste, conveyor belt	Dust	2011-12-13				
1253	3512:61	Point source	Recycling ind., electronic waste, truck	Dust	2011-12-13				
-	-	Point source	E-waste	E-waste					
-	-	Point source	Burned e-waste	E-waste					
-	-	Point source	Ash from e-waste	E-waste					
1491		Human	Female, age 36	Human serum	2012-06-12				
1492		Human	Female, age 55	Human serum	2012-06-12				
1493		Human	Female, age 60	Human serum	2012-06-12				

Lab-ID IVL	Lab-ID Umeå	Sample type	Site/Characteristics	Matrix	Start date	Stop date	X-coordinates	Y-coordinates	Specie
1494	-	Human	Female, age 43	Human serum	2012-06-12				
1495	-	Human	Male, age 58	Human serum	2012-06-12				
1496	-	Human	Male, age 28	Human serum	2012-06-12				
1497	-	Human	Female, age 47	Human serum	2012-06-12				
1498	-	Human	Male, age 37	Human serum	2012-06-12				
1499	-	Human	Male, age 40	Human serum	2012-06-12				
1500	-	Human	Male, age 42	Human serum	2012-06-12				
1501	-	Human	Male, age 30	Human serum	2012-06-12				
1502	-	Human	Female, age 46	Human serum	2012-06-12				
1503	-	Human	Male, age 59	Human serum	2012-06-12				
1577	-	Human	Male, age 41	Human serum	2012-06-28				
1578	-	Human	Male, age 62	Human serum	2012-06-28				

### Appendix 3 Results – BFRs

Lab-ID IVL	Lab-ID Umeå	Sample type	Site/Characteristics	Matrix	Date	Unit	HBB	PBT	PBEB	DBDPE	TBECH
1286	3512:39	Background	Pallas	Air	2011-July	pg/m <sup>3</sup>	0.10	<0.03	<0.2	<1.1	<0.01
1287	3512:40	Background	Pallas	Air	2012-Jan	pg/m <sup>3</sup>	<0.06	<0.02	<0.2	<0.99	<0.01
1288	3512:34	Background	Råö	Air	2011-May	pg/m <sup>3</sup>	0.21	<0.05	<0.2	<2.0	<0.01
1289	3512:35	Background	Råö	Air	2011-Aug	pg/m <sup>3</sup>	<0.16	<0.06	<0.3	<1.1	<0.01
1290	3512:36	Background	Råö	Air	2011-Sep	pg/m <sup>3</sup>	0.16	<0.03	<0.2	<1.1	<0.01
1291	-	Background	Råö	Air	2011-Nov	pg/m <sup>3</sup>	0.16	<0.04	<0.2	<1.7	<0.01
1292	3512:37	Background	Råö	Air	2012-Jan	pg/m <sup>3</sup>	<0.16	<0.06	<0.2	<2.4	<0.01
1293	3512:38	Background	Råö	Air	2012-Mar	pg/m <sup>3</sup>	<0.08	<0.03	<0.2	<1.2	<0.01
1298	3512:41	Diffuse	Järntorget, Göteborg	Air	2011-Sep	pg/m <sup>3</sup>	0.25	0.06	0.30	<1.6	0.61
1295	3512:42	Diffuse	Järntorget, Göteborg	Air	2011-Oct	pg/m <sup>3</sup>	<0.1	0.04	<0.17	<1.5	0.62
1296	3512:43	Diffuse	Järntorget, Göteborg	Air	2011-Nov	pg/m <sup>3</sup>	0.090	0.031	0.15	<1.1	0.28
1297	3512:44	Diffuse	Järntorget, Göteborg	Air	2012-Jan	pg/m <sup>3</sup>	<0.09	<0.03	<0.16	<1.4	0.19
1299	3512:46	Background	Råö	Atm. dep	2011-May	ng/m <sup>2</sup> day	<0.38	<0.03	<0.25	<2.5	<0.06
1300	3512:47	Background	Råö	Atm. dep	2011-Aug	ng/m <sup>2</sup> day	<0.38	<0.03	<0.25	<2.5	<0.06
1301	3512:48	Background	Råö	Atm. dep	2011-Sep	ng/m <sup>2</sup> day	<0.38	<0.03	<0.25	<2.5	<0.06
1302	-	Background	Råö	Atm. dep	2011-Nov	ng/m <sup>2</sup> day	<0.19	<0.01	<0.13	<2.5	<0.03
1303	3512:49	Background	Råö	Atm. dep	2012-Jan	ng/m <sup>2</sup> day	<0.38	<0.03	<0.25	<2.5	<0.06
1304	3512:50	Background	Råö	Atm. dep	2012-Mar	ng/m <sup>2</sup> day	<0.30	<0.05	<0.13	<2.5	<0.03
9593	-	Background	Kosterfjorden, Strömstad	Sediment	2011-May	ng/g dw	<0.55	<0.05	<0.35	<5	<0.13
1109	-	Background	Kullen	Biota		ng/g ww	0.19	<0.04	0.40	<0.9	0.03
1110	-	Background	Fladen	Biota		ng/g ww	0.56	<0.04	0.38	<0.9	<0.04
1111	-	Background	Väderöarna	Biota		ng/g ww	0.15	<0.05	0.67	<0.9	0.14
9602	-	Diffuse	Björkö, Göteborg	Sediment	2011-10-20	ng/g dw	<0.27	<0.02	<0.17	<2.4	<0.06
9601	-	Diffuse	Stockholmen, Göteborg	Sediment	2011-10-17	ng/g dw	<0.32	<0.03	<0.21	<2.9	<0.07
9615	-	Diffuse	Eriksberg, Göteborg	Sediment	2011-10-17	ng/g dw	0.52	0.02	0.19	<1.5	<0.04
9616	-	Diffuse	Björkö, Göteborg	Biota	2011-10-20	ng/g ww	<0.08	<0.08	1.4	<1.5	<0.08
9617	-	Diffuse	Stockholmen, Göteborg	Biota	2011-10-17	ng/g ww	<0.09	<0.09	1.5	<1.7	<0.09
9618	-	Diffuse	Eriksberg, Göteborg	Biota	2011-10-17	ng/g ww	4.6	<0.08	3.9	<1.7	<0.08
9619	-	Diffuse	Lilla Varholmen, Göteborg	Biota	2011-10-20	ng/g ww	<0.09	<0.09	0.65	<1.9	<0.09
9607	-	Diffuse	Linnégatan, Göteborg	Stormwater	2011-10-19	ng/L	2.2	<2	<2	250	<2
9608	3512:4	Diffuse	Gårda, Göteborg	Stormwater	2011-10-19	ng/L	14	<2	7.7	1300	<2
9609	3512:6	Diffuse	Odinsplatsen, Göteborg	Stormwater	2011-10-19	ng/L	22	2.2	91	1500	<2
9610	-	Diffuse	Ryaverket WWTP, Göteborg	Influent	2011-11-10	ng/L	<1.4	2.4	9.9	<70	<1.4
9611	3512:8	Diffuse	Ryaverket WWTP, Göteborg	Effluent	2011-11-10	ng/L	<1	<1	<1	<50	<1
9599	3512:9	Diffuse	Ryaverket WWTP, Göteborg	Sludge	2011-11-10	ng/g dw	1.6	0.14	0.64	63	<0.22
9613	3512:11	Diffuse	Gässlösa WWTP, Borås	Effluent	2011-11-16	ng/L	<1	<1	<1	420	<1



Lab-ID IVL	Lab-ID Umeå	Sample type	Site/Characteristics	Matrix	Date	Unit	HBB	PBT	PBEB	DBDPE	TBECH
9600	-	Diffuse	Gässlösa WWTP, Borås	Sludge	2011-11-16	ng/g dw	0.49	0.6	0.43	190	<0.1
1245	3512:51	Indoor env.	Private enterprise, office	Dust	2011-11-30	ng/g	16	1.5	<5	4000	1.3
1246	3512:52	Indoor env.	Conference centre	Dust	2012-02-08	ng/g	11	2	<3	8100	<0.71
1247	3512:53	Indoor env.	School	Dust	2011-11-22	ng/g	10	interf.	interf.	140	<0.87
1248	3512:54	Indoor env.	Private home, office	Dust	2011-11-22	ng/g	<7.5	0.72	<5.0	1300	<1.2
1249	3512:55	Indoor env.	Private home, bedroom	Dust	2011-11-22	ng/g	20	0.9	<3.0	680	<0.76
9624		Point source	Pond 1, fire extinguishing water	Water	2011-06-24	ng/L	1200	4.2	16	1600	<2
9625		Point source	Pond 2, fire extinguishing water	Water	2011-06-24	ng/L	440	<2	4.4	330	<2
9626		Point source	Ongoing fire-fighting	Water	2011-06-17	ng/L	11	<2	<2	1800	<2
1250	3512:56	Point source	New car	Dust	2012-01-25	ng/g	80	42	<43	92000	<11
1306	3512:57	Point source	Recycling ind., electronic waste, disassembly hall	Air	2011-12-13 - 19	pg/m <sup>3</sup>	1600	14	<11	220	8.3
1307	3512:58	Point source	Recycling ind., electronic waste, disassembly hall	Air	2011-12-19 - 27	pg/m <sup>3</sup>	1400	25	12	530	6.7
1252	3512:60	Point source	Recycling ind., electronic waste, conveyor belt	Dust	2011-12-13	ng/g	8200	64	16	23000	2.8
1253	3512:61	Point source	Recycling ind., electronic waste, truck	Dust	2011-12-13	ng/g	1200	5.4	9.1	20000	1.3
1491		Human	Female, age 36	Human serum	2012-06-12	ng/g	<0.025	<0.025	<0.025	<2.5	<0.025
1492		Human	Female, age 55	Human serum	2012-06-12	ng/g	<0.025	<0.025	<0.025	<2.5	<0.025
1493		Human	Female, age 60	Human serum	2012-06-12	ng/g	<0.025	<0.025	<0.025	<2.5	<0.025
1494		Human	Female, age 43	Human serum	2012-06-12	ng/g	<0.025	<0.025	<0.025	<2.5	<0.025
1495		Human	Male, age 58	Human serum	2012-06-12	ng/g	<0.025	<0.025	<0.025	<2.5	<0.025
1496		Human	Male, age 28	Human serum	2012-06-12	ng/g	<0.025	<0.025	<0.025	<2.5	<0.025
1497		Human	Female, age 47	Human serum	2012-06-12	ng/g	<0.025	<0.025	<0.025	<2.5	<0.025
1498		Human	Male, age 37	Human serum	2012-06-12	ng/g	<0.025	<0.025	0.072	<2.5	<0.025
1499		Human	Male, age 40	Human serum	2012-06-12	ng/g	<0.025	<0.025	<0.025	<2.5	<0.025
1500		Human	Male, age 42	Human serum	2012-06-12	ng/g	<0.025	<0.025	<0.025	<2.5	<0.025
1501		Human	Male, age 30	Human serum	2012-06-12	ng/g	<0.025	<0.025	<0.025	<2.5	<0.025
1502		Human	Female, age 46	Human serum	2012-06-12	ng/g	<0.025	<0.025	<0.025	<2.5	<0.025
1503		Human	Male, age 59	Human serum	2012-06-12	ng/g	<0.025	<0.025	<0.025	<2.5	<0.025
1577		Human	Male, age 41	Human serum	2012-06-28	ng/g	<0.025	<0.025	<0.025	<2.5	<0.025
1578		Human	Male, age 62	Human serum	2012-06-28	ng/g	<0.025	<0.025	<0.025	<2.5	<0.025

## Appendix 4 Results – PBDD/Fs

Lab-ID IVL	Lab-ID Umeå	Sample type	Site/Characteristics	Matrix	Date	Unit	2378- TBDD	12378- PeBDD	123478+123 678-HxBDD	123789 - HxBDD	123467 8- HpBDD	OctaB DD	2378- TBDF	12378- PeBDF	23478- PeBDF	123478 -HxBDF	1234678- HpBDF	Octa BDF
-	3512:13	Background	Råö	Air	2011-06-13 - 15	fg/m <sup>3</sup>	1.2	1.8	<10	<5	<10	<40	3.7	2.1	2.9	7.8	47	interf.
-	3512:18	Background	Råö	Air	2011-06-24 - 27	fg/m <sup>3</sup>	0.59	0.88	2.0	0.51	1.6	<5	1.0	<0.5	3.5	2.9	30	interf.
-	3512:20	Background	Råö	Air	2011-06-29 -07-01	fg/m <sup>3</sup>	2.3	1.1	<10	9.9	6.3	<20	4.7	4.1	1.7	47	72	interf.
-	3512:21	Background	Råö	Air	2011-07-01 - 04	fg/m <sup>3</sup>	0.52	0.67	0.58	0.16	3.5	<5	0.76	0.73	0.87	2.9	11	interf.
-	3512:22	Background	Råö	Air	2011-07-04 - 06	fg/m <sup>3</sup>	0.26	0.64	2.1	3.0	4.6	<150	1.8	0.56	3.2	9.0	48	interf.
-	3512:24	Background	Råö	Air	2011-11-30 - 12-02	fg/m <sup>3</sup>	0.62	0.67	3.2	23	<5	<40	4.1	4.2	6.9	17	220	interf.
-	3512:26	Background	Råö	Air	2011-12-05 - 07	fg/m <sup>3</sup>	0.49	0.65	2.4	1.3	5.7	4.7	0.88	<0.5	2.4	1.6	34	160
-	3512:28	Background	Råö	Air	2011-12-09 - 12	fg/m <sup>3</sup>	0.24	0.71	1.4	0.70	<5	20	1.7	1.4	1.9	5.1	31	interf.
-	3512:30	Background	Råö	Air	2011-12-14 - 16	fg/m <sup>3</sup>	0.3	<0.5	<2	<1	<5	<10	3.1	1.4	3.0	9.3	62	<100
-	3512:31	Background	Råö	Air	2011-12-16 - 19	fg/m <sup>3</sup>	<0.5	<0.5	<2	<1	2.2	<10	2.2	<0.5	1.2	3.1	60	85
1286	3512:39	Background	Pallas	Air	2011-July	fg/m <sup>3</sup>	0.059	0.049	0.51	0.39	0.65	<5	0.21	<0.5	<0.5	<1	4.9	6.8
1287	3512:40	Background	Pallas	Air	2012-Jan	fg/m <sup>3</sup>	0.10	0.13	0.19	0.048	0.82	<5	0.55	<0.5	<0.5	1.4	8.1	19
-	3512:33	Background	Råö	Air	2011-Mar	fg/m <sup>3</sup>	0.32	<0.5	<1	<0.5	0.50	<5	1.7	0.83	1.3	3.0	28	11
1288	3512:34	Background	Råö	Air	2011-May	fg/m <sup>3</sup>	<0.1	0.049	0.14	<0.5	0.42	<5	0.20	<0.5	<0.5	<1	6.4	interf.
1289	3512:35	Background	Råö	Air	2011-Aug	fg/m <sup>3</sup>	0.37	0.58	0.20	<0.5	1.8	<5	0.93	<0.5	1.0	2.8	21	51
1290	3512:36	Background	Råö	Air	2011-Sep	fg/m <sup>3</sup>	0.18	0.082	0.50	<0.5	0.35	<5	0.69	0.63	0.92	3.3	23	25
1292	3512:37	Background	Råö	Air	2012-Jan	fg/m <sup>3</sup>	0.14	0.14	0.14	1.1	1.0	<5	1.7	<0.5	0.94	4.0	28	59
1293	3512:38	Background	Råö	Air	2012-Mar	fg/m <sup>3</sup>	0.11	0.068	0.19	0.23	0.75	<5	0.89	0.74	0.90	3.8	19	14
1298	3512:41	Diffuse	Järntorget, Göteb.	Air	2011-Sep	fg/m <sup>3</sup>	0.032	0.023	0.22	0.034	1.2	<5	<0.1	<0.5	<0.5	<1	0.97	interf.
1295	3512:42	Diffuse	Järntorget, Göteb.	Air	2011-Oct	fg/m <sup>3</sup>	0.10	0.26	0.076	0.14	1.1	<5	2.4	0.86	1.5	4.6	30	12
1296	3512:43	Diffuse	Järntorget, Göteb.	Air	2011-Nov	fg/m <sup>3</sup>	0.16	0.11	0.18	0.11	1.3	<5	4.0	1.5	2.5	5.5	71	interf.
1297	3512:44	Diffuse	Järntorget, Göteb.	Air	2012-Jan	fg/m <sup>3</sup>	0.075	<0.1	<0.5	<0.5	0.75	<5	1.9	0.73	1.4	2.6	28	interf.
-	3512:45	Background	Råö	Atm. dep	2011-Mar	pg/m <sup>2</sup> day	0.019	<0.05	0.15	<0.5	0.29	<1	0.12	0.066	<0.5	0.59	2.3	interf.
1299	3512:46	Background	Råö	Atm. dep	2011-May	pg/m <sup>2</sup> day	0.85	0.94	1.9	<0.5	0.31	3.6	1.2	0.93	1.9	6.0	109	220
1300	3512:47	Background	Råö	Atm. dep	2011-Aug	pg/m <sup>2</sup> day	0.031	<0.05	<1	<0.5	0.72	<1	0.13	0.14	<0.5	0.38	2.7	interf.
1301	3512:48	Background	Råö	Atm. dep	2011-Sep	pg/m <sup>2</sup> day	0.076	0.18	<1	<0.5	1.2	<1	0.22	0.11	<0.5	<1	4.9	3.8
1303	3512:49	Background	Råö	Atm. dep	2012-Jan	pg/m <sup>2</sup> day	0.091	<0.05	<1	<0.5	0.42	<1	0.41	0.11	<0.5	0.66	4.6	interf.
1304	3512:50	Background	Råö	Atm. dep	2012-Mar	pg/m <sup>2</sup> day	0.048	0.13	<1	<0.5	0.54	0.43	0.22	0.14	<0.5	0.37	6.9	5.8
-	3512:01	Diffuse	Linnégatan, Göteb.	Strm w sludge	2011-10-19	pg/g	0.41	0.49	0.59	<1	<1	<5	0.89	0.3	0.61	2.3	23	interf.
-	3512:03	Diffuse	Gårda, Göteb.	Strm w sludge	2011-10-19	pg/g	0.30	0.56	<0.5	<1	<1	<5	0.95	3.5	1.3	<0.5	69	interf.
-	3512:05	Diffuse	Odinspl., Göteb.	Strm w sludge	2011-10-19	pg/g	0.27	0.66	1.9	<1	<1	<5	1.0	0.83	1.5	1.3	82	interf.
9610	3512:7	Diffuse	Ryaverket WWTP	Influent	2011-11-10	pg/L	0.15	<0.5	<1	<1	<1	2.5	2.8	0.59	0.73	5.0	34	interf.
9611	3512:8	Diffuse	Ryaverket WWTP	Effluent	2011-11-10	pg/L	0.038	<0.5	<1	<0.5	<1	<5	1.0	0.40	0.46	2.0	13	24
9599	3512:9	Diffuse	Ryaverket WWTP	Sludge	2011-11-10	pg/g dw	0.14	0.48	1.7	3.4	4.2	13	0.89	6.1	1.4	9.3	140	interf.
-	3512:10	Diffuse	Gässlösa WWTP	Influent	2011-11-16	pg/L	<0.1	<0.5	<0.5	<1	<1	<5	1.8	0.64	0.67	3.1	22	<100
9613	3512:11	Diffuse	Gässlösa WWTP	Effluent	2011-11-16	pg/L	0.051	0.068	<1	<0.5	<1	<5	2.6	0.48	1.0	2.4	14	<20
9600	3512:12	Diffuse	Gässlösa WWTP	Sludge	2011-11-16	pg/g dw	0.22	<0.5	<0.5	2.6	5.0	13	0.95	1.3	0.97	5.0	97	interf.

Lab-ID IVL	Lab-ID Umeå	Sample type	Site/Characteristics	Matrix	Date	Unit	2378- TBDD	12378- PeBDD	123478+123 678-HxBDD	123789 - HxBDD	123467 8- HpBDD	OctaB DD	2378- TBDF	12378- PeBDF	23478- PeBDF	123478 -HxBDF	1234678- HpBDF	Octa BDF
1245	3512:51	Indoor env.	Private enterprise, office	Dust	2011-11-30	pg/g	1.7	3.4	1.9	1.0	85	190	12	15	30	1100	76000	32000
1246	3512:52	Indoor env.	Conference centre	Dust	2012-02-08	pg/g	0.44	1.2	1.6	1.3	28	54	5.6	3.4	4.1	39	6300	8900
1247	3512:53	Indoor env.	School	Dust	2011-11-22	pg/g	3.0	3.3	10	8.3	22	<20	11	6.4	7.1	28	803	1500
1248	3512:54	Indoor env.	Private home, office	Dust	2011-11-22	pg/g	4.9	4.5	<20	<10	<10	interf.	120	79	120	540	4900	interf.
1249	3512:55	Indoor env.	Private home, bedroom	Dust	2011-11-22	pg/g	0.56	0.57	<10	<5	14	<20	3.0	4.9	5.8	54	1200	interf.
9624		Point source	Pond 1, fire extinguishing water	Water	2011-06-24	pg/L	<2	<2	<2	<2	<2	78	44	19	49	306	7400	5500
9625		Point source	Pond 2, fire extinguishing water	Water	2011-06-24	pg/L	<2	<2	<2	<2	8.6	90	72	37	97	560	12000	8500
9626		Point source	Ongoing fire-fighting	Water	2011-06-17	pg/L	<20	<20	<20	<20	40	75	160	73	108	430	7200	3500
1250	3512:56	Point source	New car	Dust	2012-01-25	pg/g	10	17	107	130	840	7500	54	250	580	20300	1100000	2200000
-	3512:63		Recycling ind. (BFR fraction)	Plastic	2012-May	pg/g	19	49	380	150	7300	3600	620	870	1500	41000	1400000	540000
-	3512:62		Recycling ind. (ABS, HIPS, PP fraction)	Plastic	2012-May	pg/g	1.1	1.3	7.7	9.5	36	530	31	19	95	1300	34000	350000
1306	3512:57	Point source	Recycling ind., electronic waste, disassembly hall	Air	2011-12-13 - 19	fg/m <sup>3</sup>	2.9	<5	<100	<50	47	53	6.2	3.7	7.2	79	980	1300
1307	3512:58	Point source	Recycling ind., electronic waste, disassembly hall	Air	2011-12-19 - 27	fg/m <sup>3</sup>	4.3	6.2	7.8	4.1	38	33	7.2	7.9	8.6	39	740	1300
-	3512:59	Point source	Recycling ind., electronic waste, disassembly hall	Dust	2011-12-13	pg/g	13	8.3	33	44	410	1900	630	360	740	930	45000	130000
1252	3512:60	Point source	Recycling ind., electronic waste, conveyor belt	Dust	2011-12-13	pg/g	31	8.5	1100	140	670	1500	11000	26000	3300	10600	140000	580000
1253	3512:61	Point source	Recycling ind., electronic waste, truck	Dust	2011-12-13	pg/g	13	42	140	73	1100	3000	2200	1200	5100	5200	150000	1060000
	3538:12	Human		Human milk		pg/g ww	<0.02	<0.02	<0.04	<0.02	<0.04	<0.2	<0.02	<0.02	<0.02	<0.02	<0.04	<0.2
	3538:13	Human		Human milk		pg/g ww	<0.02	<0.02	<0.04	<0.02	<0.04	<0.2	<0.02	<0.02	<0.02	<0.02	<0.04	<0.2
	3538:14	Human		Human milk		pg/g ww	<0.02	<0.02	<0.04	<0.02	<0.04	<0.2	<0.02	<0.02	<0.02	<0.02	<0.04	<0.2
	3538:15	Human		Human milk		pg/g ww	<0.02	<0.02	<0.04	<0.02	<0.04	<0.2	<0.02	<0.02	<0.02	<0.02	<0.04	<0.2
	3538:16	Human		Human milk		pg/g ww	<0.02	<0.02	<0.04	<0.02	<0.04	<0.2	<0.02	<0.02	<0.02	<0.02	<0.04	<0.2
	3538:17	Human		Human milk		pg/g ww	<0.02	<0.02	<0.04	<0.02	<0.04	<0.2	<0.02	<0.02	<0.02	<0.02	<0.04	<0.2
	3538:18	Human		Human milk		pg/g ww	<0.02	<0.02	<0.04	<0.02	<0.04	<0.2	<0.02	<0.02	<0.02	<0.02	<0.04	<0.2
	3538:19	Human		Human milk		pg/g ww	<0.02	<0.02	<0.04	<0.02	<0.04	<0.2	<0.02	<0.02	<0.02	<0.02	<0.04	<0.2
	3538:20	Human		Human milk		pg/g ww	<0.02	<0.02	<0.04	<0.02	<0.04	<0.2	<0.02	<0.02	<0.02	<0.02	<0.04	<0.2
	3538:21	Human		Human milk		pg/g ww	<0.02	<0.02	<0.04	<0.02	<0.04	<0.2	<0.02	<0.02	<0.02	<0.02	<0.04	<0.2

## Results – PBDD/Fs totals

Lab-ID IVL	Lab-ID Umeå	Sample type	Site/Characteristics	Matrix	Date	Unit	TBDD- tot	PeBDD- tot	HxBDD-tot	HpBDD -tot	OctaB DD	Σ PBDD	TBDF- tot	PeBDF- tot	HxBDF- tot	HpBDF -tot	OctaBDF	Σ PBDF
-	3512:13	Background	Råö	Air	2011-06-13 - 15	fg/m <sup>3</sup>	4.8	21	<20	<20	<40	26	29	87	320	130	interf.	570
-	3512:18	Background	Råö	Air	2011-06-24 - 27	fg/m <sup>3</sup>	1.9	<5	<10	3.0	<5	4.9	11	9.2	49	30	interf.	69
-	3512:20	Background	Råö	Air	2011-06-29 -07-01	fg/m <sup>3</sup>	13	20	<150	10	<20	310	74	120	310	110	interf.	610
-	3512:21	Background	Råö	Air	2011-07-01 - 04	fg/m <sup>3</sup>	1.9	4.7	31	5.9	<5	44	7.8	18	50	15	interf.	91
-	3512:22	Background	Råö	Air	2011-07-04 - 06	fg/m <sup>3</sup>	<5	<5	<30	<30	<150		92	77	79	48	interf.	300
-	3512:24	Background	Råö	Air	2011-11-30 - 12-02	fg/m <sup>3</sup>	5.6	<5	<100	<10	<40	110	130	330	410	280	interf.	1200
-	3512:26	Background	Råö	Air	2011-12-05 - 07	fg/m <sup>3</sup>	2.3	3.8	0.58	11	4.7	22	11	34	77	45	160	330
-	3512:28	Background	Råö	Air	2011-12-09 - 12	fg/m <sup>3</sup>	3.2	<5	<5	<10	20	23	41	39	58	31	interf.	140
-	3512:30	Background	Råö	Air	2011-12-14 - 16	fg/m <sup>3</sup>	<5	<5	<20	<10	<10		42	100	140	78	<100	360
-	3512:31	Background	Råö	Air	2011-12-16 - 19	fg/m <sup>3</sup>	<5	<10	<20	<10	<10		52	110	78	60	85	380
1286	3512:39	Background	Pallas	Air	2011-July	fg/m <sup>3</sup>	<1	<5	<10	<10	<5		4.3	9.1	12	7.5	6.8	39
1287	3512:40	Background	Pallas	Air	2012-Jan	fg/m <sup>3</sup>	<1	<5	<10	<10	<5		16	23	22	12	19	92
-	3512:33	Background	Råö	Air	2011-Mar	fg/m <sup>3</sup>	<1	<5	<10	<10	<5		44	120	81	31	11	290
1288	3512:34	Background	Råö	Air	2011-May	fg/m <sup>3</sup>	<1	<5	<10	<10	<5		7.8	8.5	17	6.4	interf.	34
1289	3512:35	Background	Råö	Air	2011-Aug	fg/m <sup>3</sup>	1.3	<5	<10	<10	<5	1.3	11	38	57	30	51	190
1290	3512:36	Background	Råö	Air	2011-Sep	fg/m <sup>3</sup>	1.3	<5	<10	<10	<5	1.3	16	57	60	23	25	180
1292	3512:37	Background	Råö	Air	2012-Jan	fg/m <sup>3</sup>	1.2	<5	<10	<10	<5	1.2	49	109	86	30	59	330
1293	3512:38	Background	Råö	Air	2012-Mar	fg/m <sup>3</sup>	1.1	<5	<10	<10	<5	1.1	28	96	68	19	14	220
1298	3512:41	Diffuse	Järntorget, Göteb	Air	2011-Sep	fg/m <sup>3</sup>	<1	<5	<10	<10	<5		0.64	0.56	0.94	1.0	interf.	2.1
1295	3512:42	Diffuse	Järntorget, Göteb	Air	2011-Oct	fg/m <sup>3</sup>	1.5	<5	<10	<10	<5	1.5	70	170	106	30	12	390
1296	3512:43	Diffuse	Järntorget, Göteb	Air	2011-Nov	fg/m <sup>3</sup>	1.8	<5	<10	<10	<5	1.8	120	140	180	71	interf.	510
1297	3512:44	Diffuse	Järntorget, Göteb	Air	2012-Jan	fg/m <sup>3</sup>	1.6	<5	<10	<10	<5	1.6	63	82	89	28	interf.	260
-	3512:45	Background	Råö	Atm. dep	2011-Mar	pg/m <sup>2</sup> day	0.33	<1	<1	1.4	<1	1.7	3.8	4.4	5.6	2.3	interf.	16
1299	3512:46	Background	Råö	Atm. dep	2011-May	pg/m <sup>2</sup> day	2.8	4.7	27	1.7	3.6	39	13	48	43	106	220	430
1300	3512:47	Background	Råö	Atm. dep	2011-Aug	pg/m <sup>2</sup> day	0.75	<1	<2	1.4	0.12	2.3	2.6	2.7	4.0	2.7	interf.	12
1301	3512:48	Background	Råö	Atm. dep	2011-Sep	pg/m <sup>2</sup> day	0.27	0.46	1.0	8.1	<1	10	2.9	5.7	8.1	6.8	3.8	27
1303	3512:49	Background	Råö	Atm. dep	2012-Jan	pg/m <sup>2</sup> day	0.79	<1	<2	1.4	<1	2.2	9.3	6.9	10	4.6	interf.	31
1304	3512:50	Background	Råö	Atm. dep	2012-Mar	pg/m <sup>2</sup> day	0.21	<1	<2	4.5	0.43	5.1	8.4	23	22	7.6	5.8	67
-	3512:01	Diffuse	Linnégatan, Göteborg	Strm w sludge	2011-10-19	pg/g	1.3	0.80	<5	<5	<5		13	22	61	43	interf.	140
-	3512:03	Diffuse	Gårda, Göteborg	Strm w sludge	2011-10-19	pg/g	1.6	0.87	<5	<5	<5		34	68	150	95	interf.	350
-	3512:05	Diffuse	Odinsplatsen, Göteborg	Strm w sludge	2011-10-19	pg/g	0.91	1.2	<5	<5	<5		26	110	150	110	interf.	400
9610	3512:7	Diffuse	Ryaverket WWTP	Influent	2011-11-10	pg/L	1.1	<2	<5	<5	<5		93	65	70	36	interf.	260
9611	3512:8	Diffuse	Ryaverket WWTP	Effluent	2011-11-10	pg/L	0.31	<2	<5	<5	<5		32	48	36	28	24	170
9599	3512:9	Diffuse	Ryaverket WWTP	Sludge	2011-11-10	pg/g dw	2.6	<2	28	13	13	57	50	110	170	140	interf.	470
-	3512:10	Diffuse	Gässlösa WWTP	Influent	2011-11-16	pg/L	1.2	<2	<5	<5	<5		45	69	40	22	<100	180
9613	3512:11	Diffuse	Gässlösa WWTP	Effluent	2011-11-16	pg/L	0.48	<2	6.4	<5	<5	6.9	109	96	38	14	<20	260
9600	3512:12	Diffuse	Gässlösa WWTP	Sludge	2011-11-16	pg/g dw	2.4	<2	21	15	13	51	38	64	79	97	interf.	280

Lab-ID IVL	Lab-ID Umeå	Sample type	Site/Characteristics	Matrix	Date	Unit	TBDD- tot	PeBDD- tot	HxBDD-tot	HpBDD- tot	OctaB DD	Σ PBDD	TBDF- tot	PeBDF- tot	HxBDF- tot	HpBDF- tot	OctaBDF	Σ PBDF
1245	3512:51	Indoor env.	Private enterprise, office	Dust	2011-11-30	pg/g	89	10	40	209	190	540	250	1080	19000	75000	32000	130000
1246	3512:52	Indoor env.	Conference centre	Dust	2012-02-08	pg/g	3.4	5.4	18	47	54	130	103	240	900	6300	8900	16000
1247	3512:53	Indoor env.	School	Dust	2011-11-22	pg/g	12	17	35	36	<20	100	420	180	490	803	1500	3400
1248	3512:54	Indoor env.	Private home, office	Dust	2011-11-22	pg/g	46	42	<40	<30	interf.	89	6600	17000	13000	4900	12000	53000
1249	3512:55	Indoor env.	Private home, bedroom	Dust	2011-11-22	pg/g	6.4	5.2	66	25	<20	102	99	230	1100	1200	interf.	2600
9624		Point source	Pond 1, fire extinguishing water	Water	2011-06-24	pg/L	120	3.1	1.3	25	78	230	1300	3600	6700	7400	5500	45000
9625		Point source	Pond 2, fire extinguishing water	Water	2011-06-24	pg/L	140	7.0	8.3	90	90	340	3100	7000	13000	12000	8500	44000
9626		Point source	Ongoing fire-fighting	Water	2011-06-17	pg/L	170	<20	69	40	75	350	2700	6500	8040	7200	3500	28000
1250	3512:56	Point source	New car	Dust	2012-01-25	pg/g	130	330	2700	2700	7500	13000	940	44000	450000	110000	2200000	3800000
-	3512:63		Recycling ind, plastics (BFR fraction)	Plastic	2012-May	pg/g	330	470	2400	11000	3600	18000	27000	110000	520000	140000	540000	2600000
-	3512:62		Recycling ind, plastics (ABS, HIPS, PP fraction)	Plastic	2012-May	pg/g	6100	50	25	98	530	6800	740	3500	24000	53000	350000	430000
1306	3512:57	Point source	Recycling ind., electronic waste, disassembly hall	Air	2011-12-13 - 19	fg/m <sup>3</sup>	39	<30	<300	106	53	200	170	440	790	980	1300	3700
1307	3512:58	Point source	Recycling ind., electronic waste, disassembly hall	Air	2011-12-19 - 27	fg/m <sup>3</sup>	26	17	26	55	33	160	150	320	570	760	1300	3100
-	3512:59	Point source	Recycling ind., electronic waste, disassembly hall	Dust	2011-12-13	pg/g	1100	140	790	1300	1900	5200	9500	39000	50100	45000	130000	270000
1252	3512:60	Point source	Recycling ind., electronic waste, conveyor belt	Dust	2011-12-13	pg/g	1600	590	2200	710	1500	6600	92000	130000	290000	140000	580000	1200000
1253	3512:61	Point source	Recycling ind., electronic waste, truck	Dust	2011-12-13	pg/g	1700	820	1800	2500	3000	9800	16000	40400	80400	150000	1100000	1400000
-	-	Point source	E-waste	E-waste		ng/g	19	1.0	31	600	29	680	110	260	27	180	5.5	580
-	-	Point source	Burned e-waste	E-waste		ng/g	0.26	2.2	0.21	<0.1	<1	2.7	2500	7900	340	330	1.2	11000
-	-	Point source	Ash from e-waste	E-waste		ng/g	0.034	0.10	0.10	0.10	1.0	1.3	8.7	18	0.48	0.84	1.0	29

## Appendix 5 Results – PCDDs

Lab-ID IVL	Lab-ID Umeå	Sample type	Site/ Characteristics	Matrix	Date	Unit	2378 TeCDD	12378 PeCDD	123478 HxCDD	123678 HxCDD	123789 HxCDD	1234678 HpCDD	OCDD	TCDD- equ. upper conc.	TCDD- equ. lower conc.
-	3512:13	Background	Råö	Air	2011-06-13 - 15	fg/m <sup>3</sup>	<0.57	<3.4	<4.9	<3.7	<4	0.060	47	7.2	0.60
-	3512:18	Background	Råö	Air	2011-06-24 - 27	fg/m <sup>3</sup>	<1.1	<1.2	<1.7	<1.4	<1.5	3.6	15	3.4	0.25
-	3512:20	Background	Råö	Air	2011-06-29 -07-01	fg/m <sup>3</sup>	7.3	<9.4	<5.3	<13	<9.7	<13	30	27	12
-	3512:21	Background	Råö	Air	2011-07-01 - 04	fg/m <sup>3</sup>	<0.84	<1.2	<1.6	<1.3	<1.4	<1.7	<6.5	3.2	0.23
-	3512:22	Background	Råö	Air	2011-07-04 - 06	fg/m <sup>3</sup>	<1.9	<2.1	<3.9	<2.9	9.0	<4.3	<32	7.1	1.1
-	3512:24	Background	Råö	Air	2011-11-30 - 12-02	fg/m <sup>3</sup>	0.69	2.4	<4.6	5.8	6.0	38	77	7.3	5.8
-	3512:26	Background	Råö	Air	2011-12-05 - 07	fg/m <sup>3</sup>	<1.6	<2.1	<2.3	<18	2.1	13	39	7.9	1.9
-	3512:28	Background	Råö	Air	2011-12-09 - 12	fg/m <sup>3</sup>	<3.5	0.55	<3.6	<5.6	<5.1	31	86	36	31
-	3512:30	Background	Råö	Air	2011-12-14 - 16	fg/m <sup>3</sup>	<2.6	<3.9	<4.4	<3.9	<8.1	30	75	16	7.1
-	3512:31	Background	Råö	Air	2011-12-16 - 19	fg/m <sup>3</sup>	<1.9	<5	<9	<7.5	<8.1	22	47	14	2.4
1286	3512:39	Background	Pallas	Air	2011-July	fg/m <sup>3</sup>	<0.39	<0.43	<0.3	<0.38	<0.3	1.2	3.7	1.3	0.32
1287	3512:40	Background	Pallas	Air	2012-Jan	fg/m <sup>3</sup>	<0.18	0.33	0.34	0.39	0.51	4.3	8.0	2.5	2.3
-	3512:33	Background	Råö	Air	2011-Mar	fg/m <sup>3</sup>	0.40	2.8	1.9	4.1	4.8	410	97	21	21
1288	3512:34	Background	Råö	Air	2011-May	fg/m <sup>3</sup>	<0.42	0.77	0.11	0.92	1.0	8.7	30	2.8	2.4
1289	3512:35	Background	Råö	Air	2011-Aug	fg/m <sup>3</sup>	<0.52	0.11	<0.77	<0.71	1.1	7.2	18	2.2	1.6
1290	3512:36	Background	Råö	Air	2011-Sep	fg/m <sup>3</sup>	<0.5	1.1	<1	1.4	2.6	20	62	4.1	3.5
1292	3512:37	Background	Råö	Air	2012-Jan	fg/m <sup>3</sup>	<0.38	3.8	2.7	4.0	5.6	36	90	12	11
1293	3512:38	Background	Råö	Air	2012-Mar	fg/m <sup>3</sup>	<0.2	1.6	1.1	1.7	2.2	22	57	4.8	4.6
1298	3512:41	Diffuse	Järntorget, Göteb	Air	2011-Sep	fg/m <sup>3</sup>	<0.27	<0.3	<0.33	<0.27	<0.39	0.62	2.4	0.81	0.10
1295	3512:42	Diffuse	Järntorget, Göteb	Air	2011-Oct	fg/m <sup>3</sup>	0.45	4.1	4.3	5.2	4.6	47	120	20	20
1296	3512:43	Diffuse	Järntorget, Göteb	Air	2011-Nov	fg/m <sup>3</sup>	0.58	6.8	4.4	11	7.8	77	180	23	23
1297	3512:44	Diffuse	Järntorget, Göteb	Air	2012-Jan	fg/m <sup>3</sup>	0.34	3.4	3.6	4.3	3.6	50	140	17	17
-	3512:45	Background	Råö	Atm. dep	2011-Mar	pg/m <sup>2</sup> day	<0.13	0.83	<0.9	<0.71	<0.74	3.2	10	1.5	1.0
1299	3512:46	Background	Råö	Atm. dep	2011-May	pg/m <sup>2</sup> day	<0.55	1.0	1.2	1.3	1.2	5.5	23	3.2	2.6
1300	3512:47	Background	Råö	Atm. dep	2011-Aug	pg/m <sup>2</sup> day	0.42	<0.13	0.70	0.54	0.15	2.0	8.2	0.93	0.78
1301	3512:48	Background	Råö	Atm. dep	2011-Sep	pg/m <sup>2</sup> day	<0.21	<0.3	<0.37	<0.32	<0.3	2.8	11	1.0	0.35
1303	3512:49	Background	Råö	Atm. dep	2012-Jan	pg/m <sup>2</sup> day	<0.22	<0.32	<0.35	0.40	0.59	5.9	18	1.1	0.50
1304	3512:50	Background	Råö	Atm. dep	2012-Mar	pg/m <sup>2</sup> day	<0.12	0.23	<0.07	0.18	<0.19	2.9	19	0.69	0.54
9607	3512:2	Diffuse	Linnégatan, Göteb	Stormwater	2011-10-19	pg/L	38	190	200	180	180	210	410	440	440
9609	3512:6	Diffuse	Odinsplatsen, Göteb	Stormwater	2011-10-19	pg/L	1.7	89	83	28	32	490	2800	150	150
-	3512:01	Diffuse	Linnégatan, Göteb	Strm w sludge	2011-10-19	pg/g	<0.28	0.53	<0.68	1.1	0.65	6.9	45	1.8	1.5
-	3512:03	Diffuse	Gårda, Göteborg	Strm w sludge	2011-10-19	pg/g	<0.18	<2.1	<0.47	0.70	0.78	11	97	3.7	1.4
-	3512:05	Diffuse	Odinsplatsen, Göteb	Strm w sludge	2011-10-19	pg/g	0.70	<2.8	<0.61	44	<0.62	9.0	61	8.7	5.8
9610	3512:7	Diffuse	Ryaverket WWTP	Influent	2011-11-10	pg/L	<0.23	<0.48	<1.3	<0.97	<1.1	3.3	18	1.9	0.51
9611	3512:8	Diffuse	Ryaverket WWTP	Effluent	2011-11-10	pg/L	<0.04	<0.29	<0.77	<0.56	<0.66	2.0	11	0.83	0.037
9599	3512:9	Diffuse	Ryaverket WWTP	Sludge	2011-11-10	pg/g	<0.02	6.7	3.6	1.9	<0.55	67	580	10	10
-	3512:10	Diffuse	Gässlösa WWTP	Influent	2011-11-16	pg/L	<0.09	<0.18	<0.35	<0.28	<0.3	1.5	7.7	0.54	0.06
9613	3512:11	Diffuse	Gässlösa WWTP	Effluent	2011-11-16	pg/L	<0.06	<0.13	<0.3	<0.22	<0.24	<0.46	1.0	0.40	0.056
9600	3512:12	Diffuse	Gässlösa WWTP	Sludge	2011-11-16	pg/g	<0.39	<4.4	<1.1	3.4	1.8	89	660	8.0	3.1
1245	3512:51	Indoor env.	Private enterprise,	Dust	2011-11-30	pg/g	<2.5	<20	<4.1	10	5.0	400	2000	32	7.9

Lab-ID IVL	Lab-ID Umeå	Sample type	Site/ Characteristics	Matrix	Date	Unit	2378 TeCDD	12378 PeCDD	123478 HxCDD	123678 HxCDD	123789 HxCDD	1234678 HpCDD	OCDD	TCDD- equ. upper conc.	TCDD- equ. lower conc.
			office												
1246	3512:52	Indoor env.	Conference centre	Dust	2012-02-08	pg/g	<1.2	1.4	3.0	4.7	3.2	700	18000	18	17
1247	3512:53	Indoor env.	School	Dust	2011-11-22	pg/g	8.1	71	<13	<11	<4.3	86	720	91	84
1248	3512:54	Indoor env.	Private home, office	Dust	2011-11-22	pg/g	42	730	300	100	180	1600	5000	860	860
1249	3512:55	Indoor env.	Private home, bedroom	Dust	2011-11-22	pg/g	2.9	<26	<4.8	7.1	<1.4	250	920	36	7.3
9624		Point source	Pond 1, fire extinguishing water	Water	2011-06-24	pg/L	<1	<1	1.1	1.9	1.1	18	100		
9625		Point source	Pond 2, fire extinguishing water	Water	2011-06-24	pg/L	<1	2.0	1.6	3.5	2.6	32	171		
9626		Point source	Ongoing fire-fighting	Water	2011-06-17	pg/L	<10	11	<10	14	14	86	403		
1250	3512:56	Point source	New car	Dust	2012-01-25	pg/g	<0.77	<7.6	<1.5	<1.2	<1.4	5.1	21	9.6	0.3
-	3512:63		Recycling ind, plastics (BFR fraction)	Plastic	2012-May	pg/g	<0.4	<0.77	<1.2	<0.97	<1.1	17	200	3.4	1.8
-	3512:62		Recycling ind, plastics (ABS, HIPS, PP fraction)	Plastic	2012-May	pg/g	<0.38	0.92	<1.4	<1.2	<1.3	11	82	33	32
1306	3512:57	Point source	Recycling ind., electronic waste, disassembly hall	Air	2011-12-13 - 19	pg/m <sup>3</sup>	<0.01	<0.05	<0.06	<0.05	<0.05	<0.08	<0.4	0.11	0.003
1307	3512:58	Point source	Recycling ind., electronic waste, disassembly hall	Air	2011-12-19 - 27	pg/m <sup>3</sup>	<0.01	<0.04	<0.05	<0.03	<0.04	<0.07	<0.3	0.086	0.001
-	3512:59	Point source	Recycling ind., electronic waste, disassembly hall	Dust	2011-12-13	pg/g	1.4	34	<17	<1.6	<1.7	1000	5100	68	66
1252	3512:60	Point source	Recycling ind., electronic waste, conveyor belt	Dust	2011-12-13	pg/g	0.15	22	47	150	110	2600	9800	140	140
1253	3512:61	Point source	Recycling ind., electronic waste, truck	Dust	2011-12-13	pg/g	4.2	41	<20	320	190	3300	12000	160	160
-	3538:22	Human		Human milk		pg/g ww	0.033	0.087	<0.03	0.34	0.080	0.63	2.7		
-	3538:23	Human		Human milk		pg/g ww	0.032	0.088	0.041	0.33	0.074	0.53	2.3		
-	3538:24	Human		Human milk		pg/g ww	0.034	0.11	0.063	0.33	0.097	0.52	2.3		
-	3538:25	Human		Human milk		pg/g ww	0.028	0.093	0.046	0.21	0.057	0.32	1.6		
-	3538:26	Human		Human milk		pg/g ww	0.019	0.058	0.038	0.17	0.051	0.26	1.3		
-	3538:27	Human		Human milk		pg/g ww	<0.012	0.055	0.038	0.16	0.045	0.26	1.2		
-	3538:28	Human		Human milk		pg/g ww	0.016	0.057	0.031	0.14	0.033	0.25	1.3		
-	3538:29	Human		Human milk		pg/g ww	0.014	0.039	0.033	0.11	0.031	0.19	0.86		
-	3538:30	Human		Human milk		pg/g ww	0.015	0.061	0.029	0.11	0.031	0.19	0.89		

## Results – PCDFs

Lab-ID IVL	Lab-ID Umeå	Sample type	Site/ Characteristics	Matrix	Date	Unit	2378 TeCDF	12378 PeCDF	23478 PeCDF	123478 HxCDF	123678 HxCDF	234678- HxCDF	123789- HxCDF	123467 8 HpCDF	1234789 HpCDF	OCDF
-	3512:13	Background	Råö	Air	2011-06-13 - 15	fg/m <sup>3</sup>	<2.2	<2.5	<0.25	<2.8	5.7	<2.9	<3.3	<3.8	<4.5	45
-	3512:18	Background	Råö	Air	2011-06-24 - 27	fg/m <sup>3</sup>	0.11	0.79	0.036	<0.97	<1.3	<1.1	1.4	2.1	<1.9	<5.8
-	3512:20	Background	Råö	Air	2011-06-29 -07-01	fg/m <sup>3</sup>	9.5	5.6	9.3	5.9	<5.3	<6.4	<11	<6	<6.4	<23
-	3512:21	Background	Råö	Air	2011-07-01 - 04	fg/m <sup>3</sup>	0.89	<0.88	<0.41	<0.95	<1.3	<0.94	1.4	0.10	<1.4	<3.9
-	3512:22	Background	Råö	Air	2011-07-04 - 06	fg/m <sup>3</sup>	2.0	0.11	0.046	<2.2	<2.7	<2.3	<4.1	<3	<8.1	<37
-	3512:24	Background	Råö	Air	2011-11-30 - 12-02	fg/m <sup>3</sup>	3.4	1.4	1.3	<2.7	<3.1	2.8	<4.1	6.8	<6.6	<24
-	3512:26	Background	Råö	Air	2011-12-05 - 07	fg/m <sup>3</sup>	2.8	0.049	3.0	<1.4	<1.4	1.3	2.0	2.5	<2.2	<6.1
-	3512:28	Background	Råö	Air	2011-12-09 - 12	fg/m <sup>3</sup>	4.1	5.6	93.0	5.1	3.1	4.2	3.1	8.1	0.43	14
-	3512:30	Background	Råö	Air	2011-12-14 - 16	fg/m <sup>3</sup>	2.7	3.1	21.0	<3	<2.8	0.34	<3.3	6.4	<4.7	<12
-	3512:31	Background	Råö	Air	2011-12-16 - 19	fg/m <sup>3</sup>	3.7	<3.4	3.8	<5.7	<5.6	<5.9	<1.1	12	<12	1900
1286	3512:39	Background	Pallas	Air	2011-July	fg/m <sup>3</sup>	0.63	0.28	0.52	0.022	<0.27	0.26	0.40	0.82	<0.35	<1.2
1287	3512:40	Background	Pallas	Air	2012-Jan	fg/m <sup>3</sup>	3.1	2.0	1.9	1.8	2.6	2.2	1.0	7.4	1.3	6.1
-	3512:33	Background	Råö	Air	2011-Mar	fg/m <sup>3</sup>	4.0	6.3	35	5.8	4.5	4.8	2.4	17	4.5	16
1288	3512:34	Background	Råö	Air	2011-May	fg/m <sup>3</sup>	1.7	3.1	1.7	1.2	1.3	1.4	1.0	4.7	1.5	6.6
1289	3512:35	Background	Råö	Air	2011-Aug	fg/m <sup>3</sup>	2.3	1.7	1.5	1.1	1.2	1.4	1.1	4.6	0.12	7.6
1290	3512:36	Background	Råö	Air	2011-Sep	fg/m <sup>3</sup>	2.2	1.4	2.2	2.1	1.8	2.2	1.4	12	1.8	16
1292	3512:37	Background	Råö	Air	2012-Jan	fg/m <sup>3</sup>	6.0	7.2	8.9	5.1	6.7	6.0	2.6	18	2.5	10
1293	3512:38	Background	Råö	Air	2012-Mar	fg/m <sup>3</sup>	2.3	3.2	2.2	2.7	3.7	3.1	1.3	14	1.3	6.8
1298	3512:41	Diffuse	Järntorget, Göteborg	Air	2011-Sep	fg/m <sup>3</sup>	0.14	0.006	0.018	<0.2	<0.25	0.24	0.45	0.49	<0.32	0.084
1295	3512:42	Diffuse	Järntorget, Göteborg	Air	2011-Oct	fg/m <sup>3</sup>	7.7	12	33	6.4	9.0	7.9	2.7	25	3.2	14
1296	3512:43	Diffuse	Järntorget, Göteborg	Air	2011-Nov	fg/m <sup>3</sup>	8.4	10	18	14	16	13	10	67	7.1	37
1297	3512:44	Diffuse	Järntorget, Göteborg	Air	2012-Jan	fg/m <sup>3</sup>	44	5.5	13	6.0	8.6	7.7	2.5	19	2.9	16
-	3512:45	Background	Råö	Atm. dep	2011-Mar	pg/m <sup>2</sup> day	0.36	0.093	0.23	<0.33	<0.36	<0.39	<0.48	2.0	2.3	<3.5
1299	3512:46	Background	Råö	Atm. dep	2011-May	pg/m <sup>2</sup> day	0.53	1.0	1.6	1.4	1.4	1.3	0.88	14	1.0	20
1300	3512:47	Background	Råö	Atm. dep	2011-Aug	pg/m <sup>2</sup> day	0.48	0.29	<0.12	0.28	0.19	0.37	0.45	1.5	0.21	2.3
1301	3512:48	Background	Råö	Atm. dep	2011-Sep	pg/m <sup>2</sup> day	0.30	0.24	0.40	0.17	0.32	0.46	0.49	1.4	<0.12	1.1
1303	3512:49	Background	Råö	Atm. dep	2012-Jan	pg/m <sup>2</sup> day	0.38	0.27	0.50	0.21	0.24	0.48	0.37	1.2	<0.33	<1.2
1304	3512:50	Background	Råö	Atm. dep	2012-Mar	pg/m <sup>2</sup> day	0.32	0.21	0.36	0.22	0.21	0.33	0.22	1.3	0.20	1.4
9607	3512:2	Diffuse	Linnégatan, Göteborg	Stormwater	2011-10-19	pg/L	40	200	210	190	220	180	170	200	190	420
9609	3512:6	Diffuse	Odinsplatsen, Göteborg	Stormwater	2011-10-19	pg/L	36	13	37	39	55	44	13	470	22	340
-	3512:01	Diffuse	Linnégatan, Göteborg	Strm w sludge	2011-10-19	pg/g	0.40	0.36	0.94	0.67	0.74	0.78	0.70	7.7	1.1	13
-	3512:03	Diffuse	Gårda, Göteborg	Strm w sludge	2011-10-19	pg/g	0.66	0.91	1.5	1.3	1.3	1.2	0.85	7.7	1.1	11
-	3512:05	Diffuse	Odinsplatsen, Göteborg	Strm w sludge	2011-10-19	pg/g	0.53	<0.077	0.24	0.57	0.71	0.98	0.75	12	0.77	11
9610	3512:7	Diffuse	Ryaverket WWTP	Influent	2011-11-10	pg/L	3.6	<0.2	0.30	<0.69	<0.59	<0.68	<1	1.9	<1.7	<3
9611	3512:8	Diffuse	Ryaverket WWTP	Effluent	2011-11-10	pg/L	0.14	<0.19	<0.18	<0.42	<0.36	<0.41	<0.64	<0.76	<1.1	<0.08
9599	3512:9	Diffuse	Ryaverket WWTP	Sludge	2011-11-10	pg/g	2.2	1.2	1.6	2.7	3.5	2.6	0.92	31	1.9	71
-	3512:10	Diffuse	Gässlösa WWTP	Influent	2011-11-16	pg/L	0.34	<0.1	<0.1	<0.18	<0.17	<0.19	<0.3	0.65	<0.61	<1.6
9613	3512:11	Diffuse	Gässlösa WWTP	Effluent	2011-11-16	pg/L	0.17	0.080	0.11	<0.14	<0.13	<0.15	<0.23	0.36	<0.43	<0.97
9600	3512:12	Diffuse	Gässlösa WWTP	Sludge	2011-11-16	pg/g	1.7	1.4	0.8	1.9	2.1	2.3	1.0	24	2.0	61
1245	3512:51	Indoor env.	Private enterprise, office	Dust	2011-11-30	pg/g	3.2	2.2	<2	3.6	<3.3	7.1	<2	35	<3.5	64
1246	3512:52	Indoor env.	Conference centre	Dust	2012-02-08	pg/g	2.1	<0.73	0.78	2.8	1.5	3.8	3.2	45	8.3	430



Lab-ID IVL	Lab-ID Umeå	Sample type	Site/ Characteristics	Matrix	Date	Unit	2378 TeCDF	12378 PeCDF	23478 PeCDF	123478 HxCDF	123678 HxCDF	234678- HxCDF	123789- HxCDF	123467 8 HpCDF	1234789 HpCDF	OCDF
1247	3512:53	Indoor env.	School	Dust	2011-11-22	pg/g	<5.5	<7.1	<4.3	<8	<11	17	16	26	<4.3	65
1248	3512:54	Indoor env.	Private home, office	Dust	2011-11-22	pg/g	18	12	10	24	23	21	<1.6	88	<33	18
1249	3512:55	Indoor env.	Private home, bedroom	Dust	2011-11-22	pg/g	2.6	<3	<1.4	<3.1	<4.1	4.2	<4	17	<5	48
9624		Point source	Pond 1, fire extinguishing water	Water	2011-06-24	pg/L	2.7	2.2	5.0	4.3	3.1	4.7	2.7	interf.	2.2	16
9625		Point source	Pond 2, fire extinguishing water	Water	2011-06-24	pg/L	5.0	4.2	8.1	8.0	4.9	7.4	4.2	interf.	4.1	28
9626		Point source	Ongoing fire-fighting	Water	2011-06-17	pg/L	22	22	43	30	31	38	26	interf.	13	105
1250	3512:56	Point source	New car	Dust	2012-01-25	pg/g	0.56	<0.8	<0.5	<0.91	<1.3	<0.92	1.6	<1.2	<1.4	<4.8
-	3512:63		Recycling ind, plastics (BFR fraction)	Plastic	2012-May	pg/g	5.4	1.7	1.8	1.5	<0.66	0.76	2.1	4.1	<2	8.0
-	3512:62		Recycling ind, plastics (ABS, HIPS, PP fraction)	Plastic	2012-May	pg/g	81	22	56	32	5.4	6.3	7.9	13	3.4	22
1306	3512:57	Point source	Recycling ind., electronic waste, disassembly hall	Air	2011-12-13 - 19	pg/m <sup>3</sup>	0.027	<0.02	<0.03	<0.04	<0.05	<0.04	<0.05	<0.07	<0.07	<0.21
1307	3512:58	Point source	Recycling ind., electronic waste, disassembly hall	Air	2011-12-19 - 27	pg/m <sup>3</sup>	0.005	<0.02	<0.03	<0.03	<0.04	<0.03	<0.04	<0.05	<0.06	<0.16
-	3512:59	Point source	Recycling ind., electronic waste, disassembly hall	Dust	2011-12-13	pg/g	17	6.7	31	23	16	15	<4.4	210	15	290
1252	3512:60	Point source	Recycling ind., electronic waste, conveyor belt	Dust	2011-12-13	pg/g	27	14	130	52	48	36	19	340	33	390
1253	3512:61	Point source	Recycling ind., electronic waste, truck	Dust	2011-12-13	pg/g	41	26	36	37	19	24	<16	250	50	400
-	3538:22	Human		Human milk		pg/g ww	<0.013	<0.018	0.21	0.056	0.055	0.031	0.035	0.082	<0.028	<0.038
-	3538:23	Human		Human milk		pg/g ww	0.015	<0.011	0.20	0.060	0.051	0.038	0.026	0.075	<0.019	0.033
-	3538:24	Human		Human milk		pg/g ww	0.019	0.042	0.23	0.075	0.077	0.069	0.052	0.27	0.034	0.24
-	3538:25	Human		Human milk		pg/g ww	<0.009	0.030	0.18	0.055	0.059	0.032	0.046	0.071	0.022	0.060
-	3538:26	Human		Human milk		pg/g ww	0.015	0.021	0.15	0.054	0.051	0.042	0.043	0.097	<0.021	0.043
-	3538:27	Human		Human milk		pg/g ww	0.015	0.021	0.13	0.053	0.049	0.043	0.044	0.14	<0.021	0.060
-	3538:28	Human		Human milk		pg/g ww	0.020	0.021	0.14	0.050	0.045	0.049	0.045	0.13	<0.021	0.054
-	3538:29	Human		Human milk		pg/g ww	0.016	0.024	0.11	0.036	0.038	0.044	0.036	0.098	<0.021	0.039
-	3538:30	Human		Human milk		pg/g ww	0.015	0.018	0.15	0.046	0.048	0.042	0.031	0.12	<0.023	0.043

## Appendix 6 Results: PBDEs

Lab-ID IVL	Lab-ID Umeå	Sample type	Site/Characteristics	Matrix	Date	Unit	BDE-28	BDE-47	BDE-100	BDE-99	BDE-154	BDE-153	BDE-183	Σ 7- PBDE's	BDE-209
-	3512:13	Background	Råö	Air	2011-06-13 - 15	pg/m <sup>3</sup>	0.015	0.18	0.029	0.11	0.031	0.20	0.72	1.3	3.0
-	3512:18	Background	Råö	Air	2011-06-24 - 27	pg/m <sup>3</sup>	0.013	0.13	0.019	0.069	0.020	0.12	0.38	0.75	1.1
-	3512:20	Background	Råö	Air	2011-06-29 -07-01	pg/m <sup>3</sup>	0.024	0.25	0.036	0.11	0.019	0.070	0.23	0.74	1.5
-	3512:21	Background	Råö	Air	2011-07-01 - 04	pg/m <sup>3</sup>	0.021	0.21	0.026	0.082	0.014	0.054	0.18	0.59	0.60
-	3512:22	Background	Råö	Air	2011-07-04 - 06	pg/m <sup>3</sup>	0.032	0.17	0.032	0.079	0.064	0.29	2.9	3.5	0.15
-	3512:24	Background	Råö	Air	2011-11-30 - 12-02	pg/m <sup>3</sup>	0.013	0.068	0.018	0.066	0.045	0.18	1.2	1.6	0.023
-	3512:26	Background	Råö	Air	2011-12-05 - 07	pg/m <sup>3</sup>	0.007	0.093	0.015	0.051	0.013	0.066	0.22	0.46	0.032
1286	3512:39	Background	Pallas	Air	2011-July	pg/m <sup>3</sup>	0.030	0.27	0.020	0.12	0.011	0.043	0.12	0.61	0.33
1287	3512:40	Background	Pallas	Air	2012-Jan	pg/m <sup>3</sup>	0.003	0.12	0.044	0.28	0.047	0.085	0.16	0.74	0.69
-	3512:33	Background	Råö	Air	2011-Mar	pg/m <sup>3</sup>	0.013	0.13	0.025	0.15	0.035	0.050	0.081	0.48	0.46
1288	3512:34	Background	Råö	Air	2011-May	pg/m <sup>3</sup>	0.011	0.084	0.014	0.052	0.012	0.018	0.050	0.24	0.52
1289	3512:35	Background	Råö	Air	2011-Aug	pg/m <sup>3</sup>		0.13	<0.02	0.055					<2.4
1290	3512:36	Background	Råö	Air	2011-Sep	pg/m <sup>3</sup>	0.002	0.12	0.019	0.073	0.022	0.050	0.20	0.49	0.67
1291	-	Background	Råö	Air	2011-Nov	pg/m <sup>3</sup>		0.079	<0.02	0.11					<0.3
1292	3512:37	Background	Råö	Air	2012-Jan	pg/m <sup>3</sup>	0.009	0.13	0.029	0.13	0.026	0.040	0.11	0.47	9.3
1293	3512:38	Background	Råö	Air	2012-Mar	pg/m <sup>3</sup>	0.002	0.13	0.024	0.11	0.048	0.21	1.1	1.6	1.2
1298	3512:41	Diffuse	Järntorget, Göteborg	Air	2011-Sep	pg/m <sup>3</sup>		0.82	0.10	0.51					9.2
1295	3512:42	Diffuse	Järntorget, Göteborg	Air	2011-Oct	pg/m <sup>3</sup>	0.067	0.77	0.12	0.39	0.098	0.17	0.47	2.1	2.3
1296	3512:43	Diffuse	Järntorget, Göteborg	Air	2011-Nov	pg/m <sup>3</sup>	0.082	0.86	0.10	0.47	0.10	0.14	0.32	2.1	4.5
1297	3512:44	Diffuse	Järntorget, Göteborg	Air	2012-Jan	pg/m <sup>3</sup>	0.045	0.44	0.062	0.27	0.050	0.084	0.20	1.16	1.7
-	3512:45	Background	Råö	Atm. dep	2011-Mar	ng/m <sup>2</sup> day	0.001	0.032	0.006	0.032	0.006	0.022	0.06	0.16	0.55
1299	3512:46	Background	Råö	Atm. dep	2011-May	ng/m <sup>2</sup> day	0.002	0.035	0.008	0.038	0.011	0.061	0.19	0.35	1.0
1300	3512:47	Background	Råö	Atm. dep	2011-Aug	ng/m <sup>2</sup> day	0.002	0.040	0.007	0.035	0.007	0.024	0.10	0.21	0.61
1301	3512:48	Background	Råö	Atm. dep	2011-Sep	ng/m <sup>2</sup> day	0.004	0.034	0.008	0.046	0.012	0.048	0.16	0.31	0.76
1302	-	Background	Råö	Atm. dep	2011-Nov	ng/m <sup>2</sup> day		0.025	<0.006	0.036					interf.
1303	3512:49	Background	Råö	Atm. dep	2012-Jan	ng/m <sup>2</sup> day	0.003	0.14	0.030	0.14	0.021	0.036	0.10	0.48	0.50
1304	3512:50	Background	Råö	Atm. dep	2012-Mar	ng/m <sup>2</sup> day	0.002	0.044	0.011	0.043	0.015	0.011	0.029	0.15	0.52
9593	-	Background	Kosterfjorden, Strömstad	Sediment	2011-May	ng/g dw		<0.05	<0.05	<0.05					5.5
1109	-	Background	Kullen	Biota		ng/g ww		0.17	0.051	0.048					17
1110	-	Background	Fladen	Biota		ng/g ww		0.081	0.029	0.042					2.1
1111	-	Background	Väderöarna	Biota		ng/g ww		0.093	0.028	0.021					0.53
9602	-	Diffuse	Björkö, Göteborg	Sediment	2011-10-20	ng/g dw		<0.024	<0.024	<0.024					3.4
9601	-	Diffuse	Stockholmen, Göteborg	Sediment	2011-10-17	ng/g dw		<0.029	<0.029	<0.029					23
9615	-	Diffuse	Eriksberg, Göteborg	Sediment	2011-10-17	ng/g dw		0.16	0.07	0.22					44
9616	-	Diffuse	Björkö, Göteborg	Biota	2011-10-20	ng/g ww		0.022	<0.015	0.017					<0.77
9617	-	Diffuse	Stockholmen, Göteborg	Biota	2011-10-17	ng/g ww		0.099	0.032	0.067					<0.86
9618	-	Diffuse	Eriksberg, Göteborg	Biota	2011-10-17	ng/g ww		3.9	1.3	1.9					<0.83
9619	-	Diffuse	Lilla Varholmen, Göteborg	Biota	2011-10-20	ng/g ww		0.057	0.020	0.031					<0.59
9607	-	Diffuse	Linnégatan, Göteborg	Stormwater	2011-10-19	ng/l									
9608	3512:4	Diffuse	Gårda, Göteborg	Stormwater	2011-10-19	ng/l	0.70	19	7.8	28	3.9	15	15	89	270
9609	3512:6	Diffuse	Odinsplatsen, Göteborg	Stormwater	2011-10-19	ng/l									
9610	-	Diffuse	Ryaverket WWTP	Influent	2011-11-10	ng/l									

Lab-ID IVL	Lab-ID Umeå	Sample type	Site/Characteristics	Matrix	Date	Unit	BDE-28	BDE-47	BDE-100	BDE-99	BDE-154	BDE-153	BDE-183	Σ 7- PBDE's	BDE-209
9611	3512:8	Diffuse	Ryaverket WWTP	Effluent	2011-11-10	ng/l									
9599	3512:9	Diffuse	Ryaverket WWTP	Sludge	2011-11-10	ng/g dw									
9613	3512:11	Diffuse	Gässlösa WWTP	Effluent	2011-11-16	ng/l									
9600	-	Diffuse	Gässlösa WWTP	Sludge	2011-11-16	ng/g dw									
1245	3512:51	Indoor env.	Private enterprise, office	Dust	2011-11-30	ng/g	0.61	29	8.4	40	3.6	5.8	6.9	95	11000
1246	3512:52	Indoor env.	Conference centre	Dust	2012-02-08	ng/g	0.21	12	2.5	12	1.0	1.6	3.3	32	720000
1247	3512:53	Indoor env.	School	Dust	2011-11-22	ng/g	0.26	17	5.2	30	2.7	4.6	3.8	63	430
1248	3512:54	Indoor env.	Private home, office	Dust	2011-11-22	ng/g	5.9	36	5.0	21	5.5	14	61	149	120
1249	3512:55	Indoor env.	Private home, bedroom	Dust	2011-11-22	ng/g	0.32	6.2	0.80	3.3	0.32	0.61	1.2	13	110
9624		Point source	Pond 1, fire extinguishing water	Water	2011-06-24	ng/l									
9625		Point source	Pond 2, fire extinguishing water	Water	2011-06-24	ng/l									
9626		Point source	Ongoing fire-fighting	Water	2011-06-17	ng/l									
1250	3512:56	Point source	New car	Dust	2012-01-25	ng/g	5.8	56	15	84	35	150	740	1100	3600000
-	3512:63		Recycling ind, plastics (BFR fraction)	Plastic	2012-May	ng/g	14	72	13	85	43	150	710	1100	51000
-	3512:62		Recycling ind, plastics (ABS, HIPS, PP fraction)	Plastic	2012-May	ng/g	5.2	68	15	110	430	3400	17000	22000	99000
1306	3512:57	Point source	Recycling ind., electronic waste, disassembly hall	Air	2011-12-13 - 19	pg/m <sup>3</sup>	16	50	4.5	22	2.5	12	49	160	520
1307	3512:58	Point source	Recycling ind., electronic waste, disassembly hall	Air	2011-12-19 - 27	pg/m <sup>3</sup>	16	51	4.5	21	2.1	11	42	150	480
-	3512:59	Point source	Recycling ind., electronic waste, disassembly hall	Dust	2011-12-13	ng/g	56	720	130	1100	590	2200	3000	7700	41000
1252	3512:60	Point source	Recycling ind., electronic waste, conveyor belt	Dust	2011-12-13	ng/g	69	600	106	1400	870	4800	1600	9500	22000
1253	3512:61	Point source	Recycling ind., electronic waste, truck	Dust	2011-12-13	ng/g	78	660	130	1000	240	1500	4800	8500	400000
1491		Human	Female, age 36	Human serum	2012-06-12	ng/g		<0.025	<0.025	<0.02	<0.04	<0.04	<0.03		0.036
1492		Human	Female, age 55	Human serum	2012-06-12	ng/g		<0.025	<0.025	<0.02	<0.04	<0.04	<0.03		<0.01
1493		Human	Female, age 60	Human serum	2012-06-12	ng/g		<0.025	<0.025	<0.02	<0.04	<0.04	<0.03		<0.01
1494		Human	Female, age 43	Human serum	2012-06-12	ng/g		<0.025	<0.025	<0.02	<0.04	<0.04	<0.03		<0.01
1495		Human	Male, age 58	Human serum	2012-06-12	ng/g		<0.025	<0.025	<0.02	<0.04	<0.04	<0.03		<0.01
1496		Human	Male, age 28	Human serum	2012-06-12	ng/g		<0.025	<0.025	<0.02	<0.04	<0.04	<0.03		<0.01
1497		Human	Female, age 47	Human serum	2012-06-12	ng/g		<0.025	<0.025	<0.02	<0.04	<0.04	<0.03		<0.01
1498		Human	Male, age 37	Human serum	2012-06-12	ng/g		<0.025	<0.025	<0.02	<0.04	<0.04	<0.03		0.14
1499		Human	Male, age 40	Human serum	2012-06-12	ng/g		<0.025	<0.025	<0.02	<0.04	<0.04	<0.03		0.034
1500		Human	Male, age 42	Human serum	2012-06-12	ng/g		<0.025	<0.025	<0.02	<0.04	<0.04	<0.03		<0.01
1501		Human	Male, age 30	Human serum	2012-06-12	ng/g		<0.025	<0.025	<0.02	<0.04	<0.04	<0.03		<0.01
1502		Human	Female, age 46	Human serum	2012-06-12	ng/g		<0.025	<0.025	<0.02	<0.04	<0.04	<0.03		0.049
1503		Human	Male, age 59	Human serum	2012-06-12	ng/g		<0.025	<0.025	<0.02	<0.04	<0.04	<0.03		0.027
1577		Human	Male, age 41	Human serum	2012-06-28	ng/g		<0.025	<0.025	<0.02	<0.04	<0.04	<0.03		<0.01
1578		Human	Male, age 62	Human serum	2012-06-28	ng/g		<0.025	<0.025	<0.02	<0.04	<0.04	<0.03		<0.01
	3538:12	Human		Human milk		ng/g	6.6	120	33	23	2.1	32	4.5	224	22

Lab-ID IVL	Lab-ID Umeå	Sample type	Site/Characteristics	Matrix	Date	Unit	BDE-28	BDE-47	BDE-100	BDE-99	BDE-154	BDE-153	BDE-183	Σ 7- PBDE's	BDE-209
	3538:13	Human		Human milk		ng/g	0.81	7.7	2.3	1.5	0.41	7.6	4.2	24	19
	3538:14	Human		Human milk		ng/g	6.0	230	51	68	4.7	24	2.4	384	18
	3538:15	Human		Human milk		ng/g	1.8	9.8	3.3	1.8	0.48	13	4.4	35	23
	3538:16	Human		Human milk		ng/g	1.4	11	2.7	2.0	0.32	18	2.2	38	31
	3538:17	Human		Human milk		ng/g	0.9	9.4	3.1	2.1	0.39	14	2.5	32	14
	3538:18	Human		Human milk		ng/g	1.1	9.1	2.8	2.2	0.38	11	2.4	29	14
	3538:19	Human		Human milk		ng/g	1.3	6.0	1.7	1.2	0.31	20	2.1	33	18
	3538:20	Human		Human milk		ng/g	2.7	92	33	11	2.3	40	0.87	182	18
	3538:21	Human		Human milk		ng/g	2.9	20	4.8	2.9	0.55	20	0.72	15	52