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# Dioxins in atmospheric deposition: comparison of samplers

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In cooperation with Umeå University



Umeå universitet



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This report has been reviewed and approved in accordance with IVL's audited and approved management system.

## Preface

A comparison study between two different types of samplers for measurements of dioxins in atmospheric deposition has been performed by IVL Swedish Environmental Research Institute (IVL) in cooperation with Umeå University (UmU). The study has been financed by the Swedish Environmental Protection Agency by within the framework of the Swedish national monitoring program for organic contaminants in air and precipitation.

## Table of contents

Summary .....	5
Sammanfattning.....	6
Introduction .....	7
Aim .....	8
Description of the samplers.....	8
IVL-sampler .....	8
MONAS-sampler .....	8
Sampling program.....	9
Results and discussion .....	10
Presentation of results.....	10
Deposition of PCDDs/PCDFs and comparison between the samplers.....	14
Deposition of PBDDs/PBDFs .....	16
Summary and Conclusions.....	17
References .....	19
Appendix 1 .....	20

## Summary

Persistent organic pollutants (POPs) such as polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (PCDDs /PCDFs) have great potential for atmospheric long-range transport and deposition. The atmosphere is an important pathway for these contaminants to both aquatic and terrestrial environments. The Swedish national monitoring program for organic contaminants in air and precipitation includes, except PCDD/PCDFs, a large number of different substances/group of substances which differ in chemical and physical properties which not only affect their behaviour in the atmosphere and the deposition process but also the requirements on sampling methods used. This leads to great demands on the type of deposition sampler to be used in a monitoring program where the aim is to monitor several different organic substances and compromises are necessary when choosing sampler type.

The overall aim of this study is to compare two different types of deposition samplers for sampling of PCDDs/PCDFs. These two samplers, the IVL-sampler and the MONAS sampler, have quite different sampling characteristics. In addition, brominated dioxins/furans were included in the measurements in order to get an idea of their occurrence in deposition at the Swedish west coast.

The sampling program lasted for one year with 4 sampling periods with a sampling duration of 3 months. This gives results showing seasonal variation and the opportunity to estimate the annual deposition.

The overall results from this study show that:

- Differences in measured deposition fluxes were found between the two samplers with a variation in magnitude between different sampling occasions. A greater amount of dioxins/furans in deposition was measured with the MONAS sampler at three out of the four periods.
- The annual dioxin/furan deposition was about 25 % higher with the MONAS sampler compared to the IVL sampler, when LOD (limit of detection) was replaced with zero for all non-detected congeners in the sum of the congeners.
- The results from the sampling comparison for the two samplers gave a difference of 25% on annual basis which should be assessed in relation to the given analytical uncertainty which was +/-29% for all samples.

The results found here are in agreement with other comparison studies when deposition samplers with different sampling characteristics were used (Brorström-Lundén, 1995). From this and other studies we can conclude that sampling of dioxins/furans as well as for other POPs gives different deposition fluxes when using samplers with different sampling characteristics. The collection efficiency differs not only among e.g. different congeners but also between sampling occasions which differ in ambient conditions such as amounts of precipitation, ambient air temperature and atmospheric particle concentrations. The choice of the type of deposition sampler to be used must therefore depend on the purpose of the measurements and the results should be discussed in relation to the sampling methods.

# Sammanfattning

Persistenta organiska föroreningar (POPs), som polyklorerade dibenso-p-dioxiner och polyklorerade dibenzofuraner (PCDDs / PCDFs) har stor potential för atmosfärisk långdistanstransport och deposition. Atmosfären är en viktig spridningsväg för dessa föroreningar till både vatten- och markområden. Det svenska nationella övervakningsprogrammet för organiska föroreningar i luft och nederbörd innehåller, förutom PCDDs / PCDFs, ett stort antal olika ämnen och ämnesgrupper vilka skiljer sig åt både i kemiska- och fysiska egenskaper, vilket inte bara påverkar transporten i atmosfären och deponeringsprocessen utan även provtagnings metodiken. Detta ställer stora krav på den depositionsprovtagare som ska användas inom ett övervakningsprogram och kompromisser är nödvändiga vid val av provtagartyp.

Det övergripande syftet med denna studie är att jämföra två olika typer av depositionsprovtagare för provtagning av PCDDs / PCDFs. Dessa två, här kallade IVL-provtagaren och MONAS-provtagaren, skiljer sig i storlek av provtagningsyta och dess material samt i val av adsorbenter och filter, vilket påverkar provtagnings effektiviteten för olika ämnen. För att få en uppfattning om förekomsten av bromerade dioxiner/ furaner i deposition inkluderades även dessa i mätningarna.

Provtagningen pågick under ett år med fyra provtagningsperioder med en provtagningsperiod av tre 3 månader. Med detta provtagningsprogram ges säsongsvariationen och en möjlighet att uppskatta den årliga depositionen.

De övergripande resultaten från studie visar att:

- Det förekom skillnader i den uppmätta depositionen mellan de två provtagarna för olika provtagningsstillfällen. En större mängd dioxiner/ furaner uppmättes med MONAS-provtagaren vid tre av de fyra perioderna.
- Den årliga uppmätta depositionen av summan av PCDDs / PCDFsn var cirka 25% högre med MONAS-provtagaren jämfört med IVL-provtagaren,
- Resultaten från provtagningsjämförelsen för de två provtagarna gav en årlig skillnad på 25% vilket skulle bedömas i förhållande till den givna analytiska osäkerheten som var +/- 29% för samtliga prov.

Resultaten från denna studie ger i likhet med andra studier, när depositionsprovtagare med olika provtagningssegenskaper jämförts för olika POPs, skillnader i deposition med en variation mellan olika tillfällen (Brorström-Lundén, 1995). Uppsamlingseffektiviteten för olika provtagare skiljer sig inte bara mellan olika ämnen/ämnesgrupper utan beror också på faktorer som mängd, nederbörd, lufttemperatur och partikelhalter i luften. Valet av depositionsprovtagare som skall användas måste därför bero på syftet med mätningarna och resultaten ska diskuteras i förhållande till provtagningsmetoderna och även ställas i relation till andra mät- och analysfel.

# Introduction

Persistent organic pollutants (POPs), includes a large number of chemicals/chemical groups which have great potential for atmospheric long-range transport. Deposition of POPs from the atmosphere is an important pathway for these contaminants to environments, both far from and close to their source areas, where they may have adverse effects both on ecosystems and humans (UNEP 2014). Many POPs are semi-volatile, and as such, they can be transported in the atmosphere either in the gas- or particulate phases and the distribution between the phases thereby affecting their potential for long-range transport as well as their deposition process (Bidleman 1988).

Deposition of POPs may take place both as wet and dry deposition. To be able to specify the share of POPs in precipitation a wet only sample should be used, while a passive collector is open (bulk sampler) to the atmosphere all the time and will give an unspecified estimate of both wet and dry deposition (Brorström-Lundén 1995). A sampler could be equipped with a filter for collection of substances on particles and an adsorbent for collection of substances dissolved in the precipitation. Different adsorbents have different collection efficiency for different substances.

Factors that affect the sampling efficiency of POPs are the physical and chemical properties of the substances such as volatility, the water solubility, lipophilicity and the partitioning between octanol and water, also factors such as air temperature and amount of rainfall matters.

Different types of deposition samplers for POPs vary in shape and surface characteristic which may affect the deposition in a different way to that occurring in the environment. The sampling characteristic is influenced by size and depth of the sampler and the material must be non-contaminating and inert. Due to the often low atmospheric concentrations of POPs the size of the collection surface (funnel) is important.

Several studies have shown that the type of deposition sampler used can affect the measurement results so these should be discussed in relation to the sampling methodology (Brorström-Lundén, 1995; Daneshvar and Wiberg, 2013).

Long-term monitoring of POPs in air and deposition is a powerful tool for following up on present levels, temporal trends and for assessing atmospheric transport processes and the pathways of POPs, e.g. to remote areas. Data from national monitoring programmes are reported and used within EMEP (Co-operative programme for monitoring and evaluating the long-range transmission of air pollutants in Europe) and AMAP (Arctic Monitoring Assessment Programme) to support international strategies and protocols. Long-term measurements are also used to identify source areas and to obtain information on developing follow-up policies to reduce emissions.

The Swedish national monitoring program for organic contaminants in air and precipitation, which started in 1995, includes a large number of different substances/group of substances such as polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs) organochlorine pesticides (OCPs), brominated flame retardance and poly fluorinated substances (PFAS) (Sjöberg et al., 2016). These substances differ in chemical and physical properties which not only affect their behaviour in the atmosphere and the deposition process but also the sampling conditions. This makes great demands on the type of deposition sampler to be used in a monitoring program and compromises are necessary when choosing sampler type. In addition, a revision of the program is made on regular bases when new substances are added to the program.

Polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (PCDDs /PCDFs) were included in the Swedish monitoring program 2009. PCDDs /PCDFs are well-known contaminants and for which atmospheric transport and deposition have shown to be important for their occurrence in the Swedish environment (Wiberg et al., 2013). This group of contaminants contains various congeners which differ in chlorination degree and chlorination pattern which affect their behaviour in the atmosphere and their deposition process. PCDDs/PCDFs are in the air to a great share present bound to particles, thus the deposition of dioxins primarily occurs via dry or wet particle deposition.

## Aim

The overall aim of this study is to compare two different types of deposition samplers for dibenzo-p-dioxins and polychlorinated dibenzofurans (PCDDs/PCDFs). The two samplers, the IVL-sampler and the MONAS samplers, are described below.

In addition, brominated dioxins/furans were included in the measurements in order to get an idea of their occurrence in deposition at the Swedish west coast. The brominated compounds were only measured with the MONAS sampler.

## Description of the samplers

### IVL-sampler

The IVL sampler, which is used in the Swedish monitoring program, is a passive sampler (bulk sampler), open to the air all the time when both wet and dry deposition is collected. This sampler consists of a 1 m<sup>2</sup> Teflon coated surface with 10 cm high edges, the bottom declines slightly towards the center where a container with an adsorbent of polyurethane foam (PUF) is attached. The particles (soot) deposited on the surface are wiped off with ethanol-moistened glass fiber filters. Thus, the deposition sample consists of both the particle-bound substances deposited on the surface of the sampler and of the substances adsorbed on the PUF-plugs. In the Swedish monitoring program the deposition samples are collected as single or two weekly samples, which then are merged into monthly samples. The IVL sampler is robust, easy to handle, is cheap and has a large collection area and PUF is an absorbent easy to handle. The sampler is usually not heated and when monitoring in cold climate the snow is collected and melted during controlled conditions. In order to obtain detectable amounts of dioxins 1-2 weeks sampling is needed.

This sampler has been used in the monitoring program since 1995, which is important for following up temporal trends. The IVL sampler is shown in Figure 1.

### MONAS-sampler

The MONAS sampler is internationally used in various measurement networks e.g. in the Czech Republic and Austria ([www.monairnet.eu](http://www.monairnet.eu)). It has a heating system and is therefore adapted to arctic conditions and has previously been used by IVL in the EU-project ArcRisk (<http://www.arcrisk.eu/>). The MONAS sampler is shown in Figure 1.



The MONAS sampler has three glass funnels that can be used in parallel. Each funnel, which has a diameter of 24 cm, is attached to a glass fiber filter for collection of substances in the particle phase and to an adsorbent for collection of substances in the precipitation. Here we use XAD-2 as the adsorbent. For the sampling of dioxins in this study all three funnels were used.

The collection area of the MONAS sampler is considerably smaller compared to the IVL sampler even if all three funnels are used, therefore longer sampling periods are needed. In this study three month sampling is used. The MONAS sampler is rather expensive and it not easy to move between sampling sites. Electricity is needed for the heating system.

The filter for particle separation makes the collection of substances in particle phase efficient and the opportunity to use different adsorbents in the different funnels makes it flexible for collection of different substances. The heating system gives the opportunity to use the sampler in cold climate.

However, due to small surface area a long sampling period is needed for the detection of the trace amounts of contaminants in deposition which gives low time resolution which could be limiting for the use monitoring network.



Figure 1. IVL sampler (right) and the MONAS sampler (left).

## Sampling program

The sampling was carried out during 2015 at Råö, an EMEP station at the Swedish west coast, where dioxins in air and deposition are measured within the ordinary monitoring program, with a frequency of four monthly samples per year.

The sampling periods for the comparison study are shown in Table 1. The sampling lasted for one year with 4 sampling periods with a duration of 3 months. This gives results showing seasonal variation and the opportunity to estimate the annual deposition. In order to get comparable sampling periods between the two samplers and to cover the whole year, additional samples were

collected with the IVL sampler. The additional samples were analysed and the results from the periods were combined to represent the three months periods.

The chemical analyses were carried out at the University of Umeå and the methods are given in Appendix 1.

**Table 1. Sampling periods together with amounts of precipitation and average temperature.**

	Sampling		Precipitation, mm	Average temperature, °C
	Start	Stop		
<b>Period 1</b>				
January-March	2015-01-02	2015-03-30	209	3.3
<b>Period 2</b>				
April- June	2015-03-30	2015-06-30	175	9.9
<b>Period 3</b>				
July-September	2015-06-30	2015-10-02	279	16
<b>Period 4</b>				
October-December	2015-10-02	2016-01-04	203	8.4

## Results and discussion

### Presentation of results

The results from the comparison study of the dioxin measurements with the IVL sampler and the MONAS sampler are shown in detail in Table 2 and Table 3, where the deposition of the individual congeners PCDDs/PCDFs and the sum are given as pg/m<sup>2</sup> for the 3-month periods together with the annual deposition.

The limit of detection (LOD) corresponds to a signal from the analyzer which is three times higher than the noise level. In the sum of the congeners, LOD is replaced with zero for all non-detected congeners. LOD depends on a number of factors and therefore vary somewhat from sample to sample, between different congeners and from one analysis to another. The measurement uncertainty given is valid at the limit of quantification (LOQ), defined as signals exceeding ten times the noise level, and above.

The blank concentrations for PUF and XAD-2 have been reported separately, and no subtraction is made from actual concentrations in the samples. The amounts of the dioxins were generally higher for the laboratory blanks (including the adsorbents) from the MONAS sampler compared to the IVL-samplers. The concentrations for individual congeners have been corrected according to the recovery of the <sup>13</sup>C marked internal standard. The given analytical uncertainty for all samples is +/- 29%.

**Table 2. Deposition of PCDD/PCDF for each period and as the annual sum, IVL sampler.**

	<b>IVL sampler</b>	Period 1	Period 2	Period 3	Period 4	<b>Period 1-4</b>
Blank PUF	Start	2015-01-02	2015-03-30	2015-06-29	2015-09-28	2015-01-02
	Stop	2015-03-30	2015-06-29	2015-09-28	2015-12-28	2015-12-28
	Precipitation, mm	209	180	280	203	<b>870</b>
	Average temperature, °C	3.3	9.9	16	8.4	<b>9.5</b>
pg/m <sup>2</sup>	Unit	pg/m <sup>2</sup>	pg/m <sup>2</sup>	pg/m <sup>2</sup>	pg/m <sup>2</sup>	<b>pg/m<sup>2</sup></b>
<0.7	2378 TeCDD	<5	<5	<5	<5	<b>&lt;5</b>
<1	12378 PeCDD	15	<13	<11	<11	<b>15</b>
<2	123478 HxCDD	26	<10	13	21	<b>59</b>
<2	123678 HxCDD	37	<10	21	29	<b>88</b>
<2	123789 HxCDD	32	<10	13	25	<b>71</b>
<1	1234678 HpCDD	480	104	250	350	<b>1200</b>
<2	OCDD	2000	430	680	930	<b>4040</b>
<0.5	2378 TeCDF	30	4.9	23	23	<b>80</b>
<1	12378 PeCDF	27	<7	20	8.2	<b>56</b>
<1	23478 PeCDF	44	7.0	25	26	<b>100</b>
<1	123478 HxCDF	35	<10	27	37	<b>99</b>
<1	123678 HxCDF	33	<10	23	32	<b>88</b>
<1	234678-HxCDF	40	<10	26	38	<b>100</b>
<1	123789-HxCDF	13	8.1	17	17	<b>55</b>
<1	1234678 HpCDF	100	47	72	110	<b>340</b>
<2	1234789 HpCDF	12	2.5	13	17	<b>45</b>
<2	OCDF	87	24	83	130	<b>320</b>

**Table 3. Deposition of PCDD/PCDF for each period and the annual, MONAS sampler.**

	<b>MONAS sampler</b>	Period 1	Period 2	Period 3	Period 4	<b>Period 1-4</b>
Blank XAD-2	Start	2015-01-02	2015-03-30	2015-06-30	2015-10-02	<b>2015-01-02</b>
	Stop	2015-03-30	2015-06-30	2015-10-02	2016-01-04	<b>2016-01-04</b>
	Precipitation, mm	209	180	280	200	<b>870</b>
	Average temperature, °C	3.3	9.9	16	8.4	<b>9.5</b>
pg/m <sup>2</sup>	Unit	pg/m <sup>2</sup>	pg/m <sup>2</sup>	pg/m <sup>2</sup>	pg/m <sup>2</sup>	<b>pg/m<sup>2</sup></b>
<3	2378 TeCDD	<3	<3	<3	<3	<b>&lt;3</b>
<6	12378 PeCDD	36	<6	<6	32	<b>67</b>
<8	123478 HxCDD	40	<8	<8	34	<b>74</b>
<7	123678 HxCDD	71	11	<7	57	<b>140</b>
<8	123789 HxCDD	61	<8	<9	47	<b>110</b>
<5	1234678 HpCDD	760	150	130	660	<b>1700</b>
3	OCDD	2030	470	430	1800	<b>4700</b>
<2	2378 TeCDF	47	7	12	29	<b>95</b>
<6	12378 PeCDF	39	11	11	33	<b>95</b>
<7	23478 PeCDF	90	21	18	66	<b>200</b>
<8	123478 HxCDF	85	21	27	61	<b>200</b>
<8	123678 HxCDF	61	16	20	52	<b>150</b>
<9	234678-HxCDF	52	16	17	71	<b>160</b>
<14	123789-HxCDF	31	<14	<14	22	<b>53</b>
<9	1234678 HpCDF	280	80	94	240	<b>690</b>
<10	1234789 HpCDF	30	<10	13	28	<b>71</b>
22	OCDF	190	75	85	160	<b>510</b>

Deposition of PCDDs/PCDFs has also been calculated as TCDD equivalents according to WHO TEQ 2005, and the TCDD equivalents for the two samplers are given in Table 4. In the cases when not all congeners can be detected, the TCDD equivalents were normally calculated at three levels; a lower concentration limit (lower bound) where LOD is replaced with zero for all non-detected congeners, a mean concentration (medium bound) where LOD is replaced with ½ LOD and an upper concentration limit (upper bound) where LOD is directly used in the calculation of TEQ. For the periods 2, 3 and 4, for the IVL sampler 2-3 sub-samples have been combined to represent 3-month periods. Several congeners in those sub-samples were close to or below the LOD and the way to handle the detection limits affect the results. The calculated TCDD equivalents given in Table 4 contain major uncertainties due to concentrations close to the LOD for the IVL sampler. We have therefore chosen to below discuss the results as pg/m<sup>2</sup>.

**Table 4. Deposition as TCDD equivalents in pg TEQ<sub>WHO 2005</sub>/m<sup>2</sup>, for the IVL sampler and MONAS sampler.**

<b>IVL sampler</b>				
pg TEQ <sub>WHO 2005</sub> /m <sup>2</sup> TCDD equivalents	Period 1	Period 2	Period 3	Period 4
Start	2015-01-02	2015-03-30	2015-06-29	2015-09-28
Stop	2015-03-30	2015-06-29	2015-09-28	2015-12-28
Upper bound	65	29	36	51
Medium bound	63	17	26	43
Lower bound	60	5.1	28	35

<b>MONAS sampler</b>				
pg TEQ <sub>WHO 2005</sub> /m <sup>2</sup> TCDD equivalents	Period 1	Period 2	Period 3	Period 4
Start	2015-01-02	2015-03-30	2015-06-30	2015-10-02
Stop	2015-03-30	2015-06-30	2015-10-02	2016-01-04
Upper bound	120	28	29	100
Medium bound	120	22	22	100
Lower bound	120	16	16	99

The results of the deposition measurements of the brominated dioxins/furans are given in Table 5. The deposition of the PBDD/PBDF congeners is given for each period and as a sum for the whole year. Like the chlorinated dioxins/furans the blank concentrations from XAD-2 have been reported separately, and no subtraction has been made from actual concentrations in the samples.

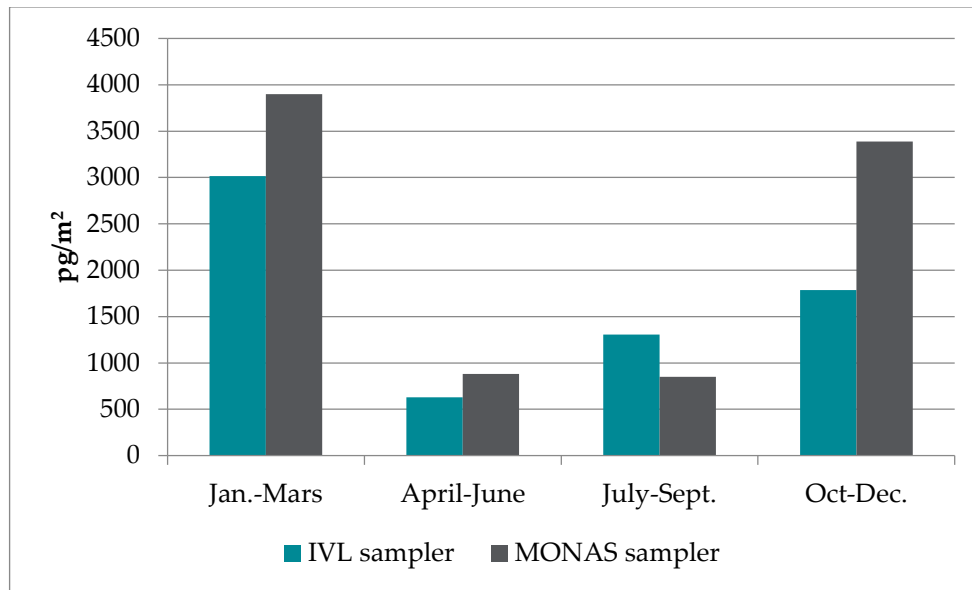
**Table 5. Deposition of PBDD/PBDF for each period and the annual sum (MONET Sampler).**

Blank XAD-2		Period 1	Period 2	Period 3	Period 4	Period 1-4
	Start	2015-01-02	2015-03-30	2015-06-30	2015-10-02	<b>2015-01-02</b>
	Stop	2015-03-30	2015-06-30	2015-10-02	2016-01-04	<b>2016-01-04</b>
	Precipitation, mm	209	180	280	203	<b>870</b>
	Average temperature, °C	3.3	9.9	16	8.4	<b>9.5</b>
<b>pg/m<sup>2</sup></b>		<b>pg/m<sup>2</sup></b>	<b>pg/m<sup>2</sup></b>	<b>pg/m<sup>2</sup></b>	<b>pg/m<sup>2</sup></b>	<b>pg/m<sup>2</sup></b>
<9	2378-TBDF	29	<9	<9	26	<b>55</b>
<14	12378-PeBDF	29	<14	<14	39	<b>68</b>
<14	23478-PeBDF	80	16	<14	80	<b>180</b>
<24	123478-HxBDF	410	<24	57	520	<b>980</b>
<240	1234678-HpBDF	3800	<240	1300	4600	<b>9700</b>
NA	OctaBDF	NA	NA	NA	NA	NA
<9	2378-TBDD	<9	<9	<9	<9	
<14	12378-PeBDD	<14	<14	<14	<14	
<50	123478+123678-HxBDD	<50	<50	<50	<50	
<24	123789-HxBDD	<24	<24	<24	<24	
<350	1234678-HpBDD	<350	<350	<350	<350	
NA	OctaBDD	NA	NA	NA	NA	

NA=not analysed. There were two problems with the analysis of PBDD and PBDF: the recovery for the furans calculated from internal standards (IS) were high, the maximum value is 249%. The other problem is the opposite. For OBDD/F, the response is so low that the IS signal cannot be safely recorded. Therefore, we choose not to report these congeners at all.

## Deposition of PCDDs/PCDFs and comparison between the samplers

The deposited amounts of chlorinated dioxins/furans, sum of the PCDDs/PCDFs, for the different sampling periods and the two samplers are shown in Figure 2.



**Figure 2. Deposition, sum of PCDDs/PCDFs, for the different sampling periods, values below LOD is replaced with zero for all non-detected congeners.**

A seasonal variation among the different sampling occasions was found with the lowest deposition during the spring and summer periods, April-September. The lowest deposition flux occurred during April-June, the period with the smallest precipitation. The greatest deposition occurred during the period, January to March, together with the lowest average ambient temperature.

A variation in the measured deposition of the dioxins was found between the two samplers for different sampling periods. A greater deposition was measured at three out of the four periods with the MONAS sampler compared to the IVL sampler and the greatest differences occurred during the winter periods.

The total annual deposition, the sum of the PCDDs/PCDFs, was 9000 pg/m² with the MONAS sampler compared to 6700 pg/m² for the IVL sampler. Thus the measured annual deposition was about 25 % higher with the MONAS sampler compared to the IVL sampler. Many of the individual congeners in the deposition were close to or below the detection limit, why the way to treat substances below the detection limit in the summation of the PCDDs/PCDFs may affect the results.

The distribution among the congeners was similar for the different sampling occasions. Thus no clear seasonal variation was identified. All individual congeners are given in Table 2 and Table 3.

The PCDDs were dominated by OCDD and 1234678 HpCDD while the low chlorinated and more toxics congeners occurred in lower amounts and 2,3,78 -TCDD was not detected at all. Most of the PCDFs congeners occurred in the deposition where 1234789 HpCDF and OCDF occurred in the greatest share.

The percentage distribution of the annual averages of the individual PCDDs and PCDFs for the two samplers is shown in Figure 3.

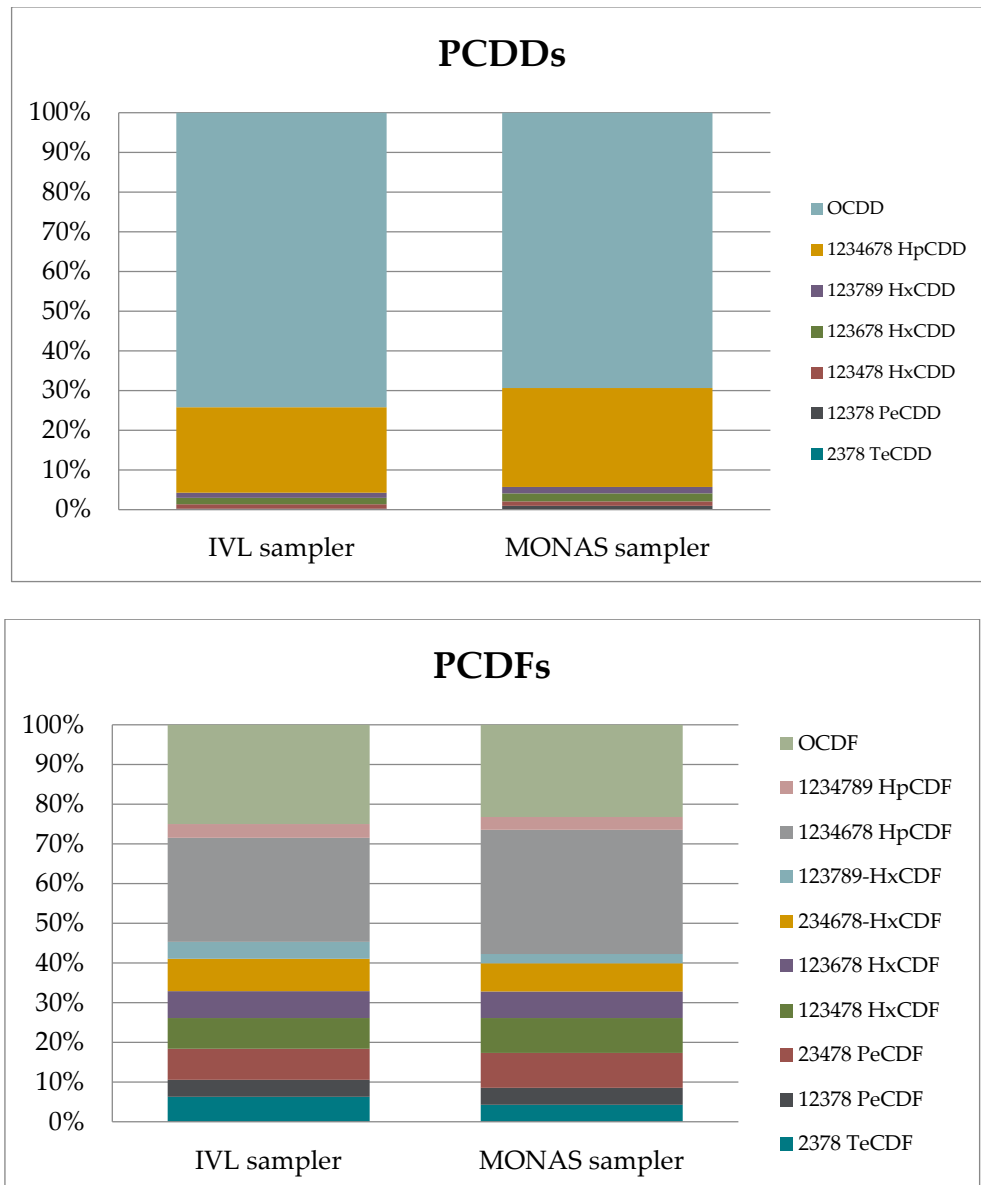


Figure 3. The percentage distribution of the annual averages for individual PCDDs and PCDFs.

Similar distribution among the different congeners was found for the two samplers. The share of the more volatile congeners were however somewhat greater for the IVLs sampler.

## Deposition of PBDDs/PBDFs

As mentioned above the occurrence of brominated dioxins/furans (PBDDs/PBDFs) in deposition at the Swedish west coast was analysed in the samples from the MONAS sampler. The results are given in Table 5.

PBDFs occurred mainly during winter periods, 234678-HpBDF occurred in greatest amounts and PBDDs were not detected at all.



## Summary and Conclusions

Two deposition samplers with quite different sampling characteristics have been compared for sampling of dioxins and furans. The results from this study show that:

- Differences in measured deposition fluxes were found between the two samplers with a variation in magnitude between different sampling occasions. A greater amount of dioxins/furans in deposition was measured with the MONAS sampler at three out of the four periods.
- The annual dioxin/furan deposition was about 25 % higher with the MONAS sampler compared to the IVL sampler, when LOD was replaced with zero for all non-detected congeners in the sum of the congeners.
- Several congeners were close to or below the LOD and the way to handle the detection limits affect the results. This is illustrated for deposition fluxes calculated as TCDD equivalents.
- No subtraction of blank concentrations was made from actual concentrations in the samples. The amounts of the dioxins were generally higher for the laboratory blank from the MONAS sampler compared with the IVL-samplers.
- The results from the sampling comparison for the two samplers gave a difference of 25% on annual basis which should be assessed in relation to the given analytical uncertainty which was +/-29% for all samples.

The results found here are in agreement with other comparison studies when deposition samplers with such different sampling characteristics were used (Brorström-Lundén 1995). In a Nordic inter comparison carried out already 1991, five different deposition samplers for collection of semivolatile organic substances were tested. This study showed a variation in the measured deposition among different samplers both for different compounds and between different sampling occasions. The relative standard deviation between the five samplers at five different sampling periods varied between 33%-72% for PCBs (sum seven) and 39%-81% for HCHs (alpha and gamma).

In a limited field study, which included analyses of dioxins/furans, two deposition samplers with quite different sampling characteristics, the IVL sampler and a sampler equipped with a glass fiber filter (no adsorbent) were compared (Daneshvar and Wiberg, 2013). The sampling was undertaken at Svartberget field station (Vindeln) and included one monthly sample (February 2008). The results showed that the sampler equipped with the filter was more efficient for very hydrophobic pollutants, such as highly chlorinated PCDD/PCDFs compared to the IVL-sampler. The filter sampler collected 2.1-2.9 times higher amounts of HpCDD and OCDD and 1.3-1.5 times higher amounts of HpCDFs and OCDF. For the less chlorinated congeners, the IVL sampler was more efficient and collected 1.2-1.6 times higher amounts of tetra- and penta-CDFs (TCDFs and PCDFs) and TCDDs. However this study included only one sampling occasion during a winter period.

From this and other studies we can conclude that sampling of dioxins/furans as well as for other POPs gives different deposition fluxes when using samplers with different sampling characteristics. The collection efficiency differs not only among e.g. different congeners but also between sampling occasions which differ in ambient conditions such as amounts of precipitation, ambient air temperature and atmospheric particle concentrations. The choice of the type of deposition sampler to be used must therefore depend on the purpose of the measurements and the results should be discussed in relation to the sampling methods.

The Swedish national monitoring program for organic contaminants in air and precipitation includes a large number of different substances/substance groups and compromises for selection of deposition sampler have to be made. The results from the deposition measurements in the Swedish monitoring network are e.g. used to follow up environmental goals and to estimate the importance of atmospheric transport and deposition for the occurrence of organic contaminants in the Swedish environment. Results from the deposition measurements are also used to estimate the importance of atmospheric deposition in relation to other sources (e.g. catchment run-off and point sources) to the sea area, i.e. to dimension the “problem” of atmospheric transport and deposition. For these purposes the IVL- sampler seems adequate for dioxins. It is however important to do air sampling in parallel and evaluate the results in relation to the atmospheric concentrations.

For research purposes it is important to use a sampler adapted for special substances and issues, e.g. for studies of deposition processes a sampler which separates substances on particles and substances dissolved in precipitation must be used. It must be noted that the long sampling periods to get detectable amounts of trace contaminants may affect the original distribution between the phases.

However in validation of the deposition samplers it is important to put deviations in relation to other uncertainties e.g. analytical variation.

In studies of regional differences and other comparison of deposition fluxes of dioxins and other POPs it is essential that the same type of sampler are used.

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# Appendix 1



ISO/IEC 17025

## RAPPORT

utfärdad av ackrediterat laboratorium

REPORT issued by an Accredited Laboratory

Umeå 2016-10-10

Mpr 3691

Sida 1(19)

### UMEÅ UNIVERSITET

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## **Resultat från analys av polyklorerade dibenso-*p*-dioxiner, polyklorerade dibensofuraner (PCDD/F), polybromerade dibenso-*p*-dioxiner och polybromerade dibensofuraner (PBDD/F) i luftprover.**

Denna rapport får endast återges i sin helhet, om inte utfärdande laboratorium i förväg skriftligen godkänt annat.

*För resultat som används som underlag för myndighetsbeslut medges undantag från kravet att återge rapporten i sin helhet.*

**Förkortningar i analysrapporten**

TeC-	Tetraklor (4 klor)	-DD	Dibenso- <i>p</i> -dioxin(er)
PeC-	Pentaklor (5 klor)	-DF	Dibensofuran(er)
HxC-	Hexaklor (6 klor)		
HpC-	Heptaklor (7 klor)		
OC-	Oktaklor (8 klor)		
pg	Picogram ( $10^{-12}$ gram)		
fg	Femtogram ( $10^{-15}$ gram)		
I-TEQ	Internationella TEQ		
IS	Internstandard		
ND	Icke-detekterad (Not Detected)		
LOD	Detektionsgräns (Limit of Detection)		
LOQ	Kvantifieringsgräns (Limit of Quantification)		
TEF	Toxisk ekvivalentfaktor (Toxic Equivalency Factor)		
TEQ	Total koncentration i TCDD-ekvivalenter (TCDD toxic equivalent concentration)		
PBDD/F	Polybromerade dibenso- <i>p</i> -dioxiner/dibensofuraner		

## Metodsammanfattning

Använda upparbetnings- och analysmetoder överensstämmer med Svensk standard SS-EN 1948:2-4 för PCDD/F-analys. PBDD/F analyseras med egen metod. En sammanfattning av dessa följer nedan.

## Provberedning

Före indunstning av provextrakten tillsattes internstandard bestående av  $^{13}\text{C}$ -kongener. Dessa standarder består för PCDD/F och PBDD/F av isotopmärkta ämnen med samma egenskaper som de ämnen som analyserats men med annan molekylvikt.

## Upprening

Uppreningen av PCDD/F och PBDD/F, utfördes med två vätskekromatografikolonner:

- En flerskiktsskolonn bestående av kiselgel, svavelsyra- och kaliumhydroxidimpregnerad kiselgel.
- En aktivt kol-kolonn.

Innan den slutliga analysen tillsattes ytterligare  $^{13}\text{C}$ -kongener, sk. återfinningsstandarder.

## Analys

Isomerspecifik analys har utförts med hjälp av gaskromatografi - masspektrometri (GC-MS) och så kallad isotopspädningsteknik. Högupplösande masspektrometrar har använts. Waters Autospec Ultima opererade med elektronstötjonisering (EI) och selektiva joner registrerades (SIR).

## Kvantifiering

Vid MS-analys är det möjligt att selektivt detektera ämnen med specifika massor, vilket innebär att  $^{13}\text{C}$ -kongener kan utnyttjas som internstandarder. Kvantifieringen utfördes enligt ovan nämnda SS-EN norm. Härvidlag jämförs responskvoten mellan naturliga kongener och  $^{13}\text{C}$ -kongener i provet med motsvarande kvot i en kvantifieringsstandard innehållande kända mängder av naturliga och  $^{13}\text{C}$ -inmärkte kongener. Detta förfarande medför att de framräknade koncentrationerna är kompenserade för upparbetningsförluster eftersom dessa tillsattes före upparbetningen startade.

När en kongen ej kan detekteras räknas detektionsgränsen ut (LOD – limit of detection). Den motsvarar normalt en signal från analysinstrumentet som är tre gånger högre än brusnivån och anges som ett mindre än-värde. LOD beror av ett antal faktorer och varierar därför från prov till prov, mellan olika kongener och från ett analystillfälle till ett annat. För PCDD/F lämnas ackrediterade resultat. Kvantifieringsgränsen (LOQ – limit of quantification) definieras av signaler som överstiger tio gånger brusnivån. I området mellan tre och tio gånger brusnivån erhålls sk mätvärdesspår där mätosäkerheten är förhöjd men ändå kan ge ett värdefullt bidrag till resultaten och ingår därför i TEQ-beräkningen. Det framgår av analysrapporten för vilka kongener kriteriet för signalkvalitet enligt LOQ inte är uppfyllt.

## Beräkning av TCDD-ekvivalenter (TEQ)

Utifrån de enskilda kongenernas koncentration har s.k. TCDD-ekvivalenter (TEQ) beräknats. TCDD-ekvivalenterna relaterar de toxiska kongenerna till den mest toxiska, 2,3,7,8-TeCDD.

$$\text{TEQ} = \text{koncentration} \times \text{TEF}$$

Det finns ett antal olika TEF-skalar som använts genom åren. Idag är WHO-TEF-skalan den vedertagna, senast uppdaterad 2005, men resultaten kan omräknas enligt den skala som önskas (tabell 1.).

När en kongen ej kan detekteras räknas detektionsgränsen ut. Den motsvarar en signal från analysinstrumentet som är tre gånger högre än brusnivån. Detektionsgränsen beror av ett antal faktorer och varierar därför något från prov till prov, mellan olika kongener och från ett analystillfälle till ett annat.

TEQ beräknas på tre nivåer. En nedre koncentrationsgräns där koncentrationerna av icke detekterade ämnen satts till noll, en övre koncentrationsgräns där koncentrationerna av icke detekterade ämnen ersatts med detektionsgränsen samt en medelkoncentration (medelvärde av de båda). I analysrapportens kolumn "WHO-TEQ" har det procentuella bidraget av detekterade kongener till det totala TEQ-värdet beräknats utifrån den övre koncentrationsgränsen.

**Generell kommentar**

Ingen subtraktion har gjorts från provens koncentrationer (Laboratieblankens koncentration redovisas inte). Specifika kommentarer kring provserien och eventuella avvikelser från det ackrediterade förfarandet finns på sidan 7. Förutom den ackrediterade analysrapporten för respektive prov (sidan 8-19) finns TEQ-värden och summor för hela provserien på sidan 6.



**Tabell 1. Skalar för beräkning av toxiska ekvivalenter (TEQ):**

Kongen:	PCDD/ PCDF	Viktfaktor (TEF):				
		WHO 2005	WHO 1998	Internationell	Nordic	Eadon
2,3,7,8	-TeCDD	1	1	1	1	1
1,2,3,7,8	-PeCDD	1	1	0,5	0,5	1
1,2,3,4,7,8	-HxCDD	0,1	0,1	0,1	0,1	0,033
1,2,3,6,7,8	-HxCDD	0,1	0,1	0,1	0,1	0,033
1,2,3,7,8,9	-HxCDD	0,1	0,1	0,1	0,1	0,033
1,2,3,4,6,7,8	-HpCDD	0,01	0,01	0,01	0,01	
	OCDD	0,0003	0,0001	0,001	0,001	
2,3,7,8	-TeCDF	0,1	0,1	0,1	0,1	0,33
1,2,3,7,8	-PeCDF	0,03	0,05	0,05	0,01	0,33
2,3,4,7,8	-PeCDF	0,3	0,5	0,5	0,5	0,33
1,2,3,4,7,8	-HxCDF	0,1	0,1	0,1	0,1	0,01
1,2,3,6,7,8	-HxCDF	0,1	0,1	0,1	0,1	0,01
1,2,3,7,8,9	-HxCDF	0,1	0,1	0,1	0,1	0,01
2,3,4,6,7,8	-HxCDF	0,1	0,1	0,1	0,1	0,01
1,2,3,4,6,7,8	-HpCDF	0,01	0,01	0,01	0,01	
1,2,3,4,7,8,9	-HpCDF	0,01	0,01	0,01	0,01	
	OCDF	0,0003	0,0001	0,001	0,001	

## Resultatsammanfattning\*

<b>Vår provmärkning:</b>	3691:1	3691:2	3691:3	3691:4	3691:5	3691:6
<b>Er provmärkning:</b>	20150102-0330	20150330-0630	20150630-1002	20151002-160104	Fältblank XAD	Fältblank filter
<b>Provtyp:</b>	luft	luft	luft	luft	fältblank	fältblank
<b>Enhet:</b>	pg/prov	pg/prov	pg/prov	pg/prov	pg/prov	pg/prov
<b>PCDD och PCDF:</b>						
<b>Σ WHO-TEQ övre konc.</b>	<b>26</b>	<b>5.9</b>	<b>6.1</b>	<b>22</b>	<b>3.8</b>	<b>3.8</b>
<b>2005 medelkonc.</b>	<b>25.5</b>	<b>4.7</b>	<b>4.8</b>	<b>21.5</b>	<b>1.9</b>	<b>1.9</b>
<b>nedre konc.</b>	<b>25</b>	<b>3.4</b>	<b>3.4</b>	<b>21</b>	<b>0.0040</b>	<b>0</b>
Σ WHO 2005 TEQ <sub>diox</sub>	25-26	3.4-5.9	3.4-6.1	21-22	0.0040-3.8	0-3.8
Σ WHO 1998 TEQ <sub>diox</sub>	29-30	4.4-6.8	4.2-6.9	24-25	0.0013-4.1	0-4.1
Σ I-TEQ	26-27	4.5-6.4	4.3-6.4	21-22	0.013-3.5	0-3.5
Σ TEQ Nordic	25-26	4.4-6.3	4.2-6.3	21	0.013-3.5	0-3.5
Σ TEQ Eadon	21-22	2.9-4.9	3.0-5.2	17-18	0-3.2	0-3.2
<b>PBDD och PBDF:</b>						
<b>Σ WHO-TEQ 2005</b>	0.16-0.55	0.091-0.14	0.086-0.17	0.21-0.66	0.067-0.070	0.067-0.094

\* Omfattas ej av ackrediteringen.

## **Kommentarer**

De toxiska ekvivalenterna för bromerade dioxiner (PBDD och PBDF) i resultatsammanfattningen ovan har beräknats enligt viktfaktorerna för WHO 2005 (se tabell 1). Det finns två problem med analysen av PBDD och PBDF. Det första är att återfinningsgraderna för internstandarderna (IS) för furaner blir höga, maxvärdet är 249 %. Vi hittar ingen bra förklaring till varför men utgår från att den förhöjda IS-responsen också gäller motsvarande nativa föreningar. Vi väljer därför att använda den normala kvantifieringsrutinen där kompensationen av IS-responsen görs i beräkningen. Risken detta medför är att koncentrationerna underskattas något. Vi kan dock se att denna avvikelse finns på ett likartat sätt i hela provserien vilket gör att den relativa jämförelsen inte påverkas särskilt mycket. Det andra problemet är det motsatta. För OBDD/F är responsen så låg att IS-signalen inte går att säkert registrera. Det gör att vi inte kan kvantifiera eller bestämma detektionsgränser med säkerhet för dem. Vi ser inga nativa toppar för dessa ämnen men det innebär bara att de inte finns i förhållandevis höga koncentrationer. Därför väljer vi att inte rapportera dessa ämnen alls.

*Umeå som ovan,*

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*Per Liljelind, utförare och granskare  
Biträdande Laboratoriechef*

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*Maria Hjelt, utförare och rapportör  
Ingenjör*

## Analysrapport klorerade dioxiner och furaner

**Vår provmärkning** : 3691:1  
**Er provmärkning** : 2015-01-02-2015-03-30  
**Provtyp** : luftprov  
**Mätosäkerhet** :  $\pm 29 \%$  (95% konfidensintervall)

Kongen	pg/prov		Återfunnen <sup>13</sup> C IS (%)
	Konc.	WHO-TEQ(%)	
2378 TeCDD	ND(0.70)	2.7	92%
12378 PeCDD	7.6	29	87%
123478 HxCDD	8.4	3.2	86%
123678 HxCDD	15	5.7	83%
123789 HxCDD	13	5.1	84%
1234678 HpCDD	160	6.2	88%
OCDD	430	0.49	71%
2378 TeCDF	10	3.9	92%
12378 PeCDF	8.2	0.94	75%
23478 PeCDF <sup>a</sup>	19	22	83%
123478 HxCDF	18	6.9	85%
123678 HxCDF	13	5.1	87%
234678 HxCDF <sup>b</sup>	11	4.3	90%
123789 HxCDF <sup>c</sup>	6.6	2.5	91%
1234678 HpCDF	59	2.3	85%
1234789 HpCDF	6.4	0.25	91%
OCDF	41	0.047	75%
<b>Sum 2005 WHO-TEQ</b>	övre konc.	26	
	medelkonc.	25.5	
	nedre konc.	25	

<sup>a</sup> Sameluerar med 12369, 12489, 23467-PeCDF

<sup>c</sup> Sameluerar med 123489-HxCDF

<sup>b</sup> Sameluerar med 123689-HxCDF

*Kursiv stil* innebär mätvärdesspår, resultat med utökad mätosäkerhet upp till 75%

<b>Provet ankom:</b>	160121	<b>Typ av GC-kolonn:</b>	DB-5ms
<b>Lagringsbetingelser :</b>	Kyl	<b>Personer ansvariga för</b>	Maria Hjelt,
<b>Startdatum för</b>	160419	<b>upparbetning och analys:</b>	Per Liljelind
<b>upparbetn:</b>			
<b>Startdatum för analys:</b>	160609		

## Analysrapport klorerade dioxiner och furaner

**Vår provmärkning** : 3691:2  
**Er provmärkning** : 2015-03-30-2015-06-30  
**Provtyp** : luftprov  
**Mätosäkerhet** :  $\pm 29 \%$  (95% konfidensintervall)

Kongen	pg/prov		Återfunnen <sup>13</sup> C IS (%)
	Konc.	WHO-TEQ(%)	
2378 TeCDD	ND(0.65)	11	78%
12378 PeCDD	ND(1.2)	20	78%
123478 HxCDD	ND(1.7)	2.9	72%
123678 HxCDD	2.3	3.8	75%
123789 HxCDD	ND(1.7)	2.8	73%
1234678 HpCDD	32	5.4	75%
OCDD	100	0.51	63%
2378 TeCDF	1.5	2.5	84%
12378 PeCDF	2.4	1.2	64%
23478 PeCDF <sup>a</sup>	4.5	23	75%
123478 HxCDF	4.5	7.7	74%
123678 HxCDF	3.3	5.5	80%
234678 HxCDF <sup>b</sup>	3.4	5.8	79%
123789 HxCDF <sup>c</sup>	ND(3.0)	5.1	79%
1234678 HpCDF	17	2.8	74%
1234789 HpCDF	ND(2.1)	0.36	82%
OCDF	16	0.081	65%
<b>Sum 2005 WHO-TEQ</b>	övre konc.	5.9	
	medelkonc.	4.7	
	nedre konc.	3.4	

<sup>a</sup> Sameluerar med 12369, 12489, 23467-PeCDF

<sup>c</sup> Sameluerar med 123489-HxCDF

<sup>b</sup> Sameluerar med 123689-HxCDF

*Kursiv stil* innebär mätvärdesspår, resultat med utökad mätosäkerhet upp till 75%

<b>Provet ankom:</b>	160121	<b>Typ av GC-kolonn:</b>	DB-5ms
<b>Lagringsbetingelser :</b>	Kyl	<b>Personer ansvariga för</b>	Maria Hjelt,
<b>Startdatum för</b>	160419	<b>upparbetning och analys:</b>	Per Liljelind
<b>upparbetn:</b>			
<b>Startdatum för analys:</b>	160609		

## Analysrapport klorerade dioxiner och furaner

**Vår provmärkning** : 3691:3  
**Er provmärkning** : 2015-06-30-2015-10-02  
**Provtyp** : luftprov  
**Mätosäkerhet** :  $\pm 29 \%$  (95% konfidensintervall)

Kongen	pg/prov		Återfunnen <sup>13</sup> C IS (%)
	Konc.	WHO-TEQ(%)	
2378 TeCDD	ND(0.65)	11	75%
12378 PeCDD	ND(1.3)	21	68%
123478 HxCDD	ND(1.7)	2.8	73%
123678 HxCDD	ND(1.6)	2.6	71%
123789 HxCDD	ND(1.9)	3.0	72%
1234678 HpCDD	27	4.4	71%
OCDD	90	0.44	58%
2378 TeCDF	2.5	4.1	76%
12378 PeCDF	2.4	1.2	64%
23478 PeCDF <sup>a</sup>	3.9	19	69%
123478 HxCDF	5.8	9.5	75%
123678 HxCDF	4.2	6.8	74%
234678 HxCDF <sup>b</sup>	3.7	6.0	69%
123789 HxCDF <sup>c</sup>	ND(3.0)	4.9	77%
1234678 HpCDF	20	3.3	68%
1234789 HpCDF	2.8	0.45	75%
OCDF	18	0.089	62%
<b>Sum 2005 WHO-TEQ</b>	övre konc.	6.1	
	medelkonc.	4.8	
	nedre konc.	3.4	

<sup>a</sup> Sameluerar med 12369, 12489, 23467-PeCDF

<sup>c</sup> Sameluerar med 123489-HxCDF

<sup>b</sup> Sameluerar med 123689-HxCDF

*Kursiv stil* innebär mätvärdesspår, resultat med utökad mätosäkerhet upp till 75%

<b>Provet ankom:</b>	160121	<b>Typ av GC-kolonn:</b>	DB-5ms
<b>Lagringsbetingelser :</b>	Kyl	<b>Personer ansvariga för</b>	Maria Hjelt,
<b>Startdatum för</b>	160419	<b>upparbetning och analys:</b>	Per Liljelind
<b>upparbetn:</b>			
<b>Startdatum för analys:</b>	160609		

## Analysrapport klorerade dioxiner och furaner

**Vår provmärkning** : 3691:4  
**Er provmärkning** : 2015-10-02-2016-01-04  
**Provtyp** : luftprov  
**Mätosäkerhet** :  $\pm 29 \%$  (95% konfidensintervall)

Kongen	pg/prov		Återfunnen
	Konc.	WHO-TEQ(%)	<sup>13</sup> C IS (%)
2378 TeCDD	ND(0.65)	3.0	59%
12378 PeCDD	6.7	31	60%
123478 HxCDD	7.3	3.4	64%
123678 HxCDD	12	5.5	61%
123789 HxCDD	10	4.6	62%
1234678 HpCDD	140	6.3	61%
OCDD	380	0.53	48%
2378 TeCDF	6.1	2.8	66%
12378 PeCDF	7.1	0.99	54%
23478 PeCDF <sup>a</sup>	14	19	62%
123478 HxCDF	13	6.1	64%
123678 HxCDF	11	4.9	63%
234678 HxCDF <sup>b</sup>	15	6.9	63%
123789 HxCDF <sup>c</sup>	4.6	2.1	67%
1234678 HpCDF	51	2.3	58%
1234789 HpCDF	5.9	0.27	64%
OCDF	34	0.048	50%
<b>Sum 2005 WHO-TEQ</b>	övre konc.	22	
	medelkonc.	21.5	
	nedre konc.	21	

<sup>a</sup> Sameluerar med 12369, 12489, 23467-PeCDF

<sup>c</sup> Sameluerar med 123489-HxCDF

<sup>b</sup> Sameluerar med 123689-HxCDF

*Kursiv stil* innebär mätvärdesspår, resultat med utökad mätosäkerhet upp till 75%

<b>Provet ankom:</b>	160121	<b>Typ av GC-kolonn:</b>	DB-5ms
<b>Lagringsbetingelser :</b>	Kyl	<b>Personer ansvariga för</b>	Maria Hjelt,
<b>Startdatum för</b>	160419	<b>upparbetning och analys:</b>	Per Liljelind
<b>upparbetn:</b>			
<b>Startdatum för analys:</b>	160609		

## Analysrapport klorerade dioxiner och furaner

**Vår provmärkning** : 3691:5  
**Er provmärkning** : Fältblank XAD  
**Provtyp** : luftprov  
**Mätosäkerhet** :  $\pm 29 \%$  (95% konfidensintervall)

Kongen	pg/prov		Återfunnen <sup>13</sup> C IS (%)
	Konc.	WHO-TEQ(%)	
2378 TeCDD	ND(0.65)	17	91%
12378 PeCDD	ND(1.2)	31	88%
123478 HxCDD	ND(1.7)	4.6	85%
123678 HxCDD	ND(1.6)	4.3	90%
123789 HxCDD	ND(1.7)	4.5	86%
1234678 HpCDD	ND(1.2)	0.32	88%
OCDD	2.6	0.021	71%
2378 TeCDF	ND(0.5)	1.3	96%
12378 PeCDF	ND(1.3)	1.1	79%
23478 PeCDF <sup>a</sup>	ND(1.5)	12	82%
123478 HxCDF	ND(1.8)	4.6	86%
123678 HxCDF	ND(1.7)	4.5	94%
234678 HxCDF <sup>b</sup>	ND(2)	5.3	89%
123789 HxCDF <sup>c</sup>	ND(3)	8.1	93%
1234678 HpCDF	ND(1.9)	0.49	83%
1234789 HpCDF	ND(2.1)	0.56	93%
OCDF	11	0.085	76%
<b>Sum 2005 WHO-TEQ</b>	övre konc.	3.8	
	medelkonc.	1.9	
	nedre konc.	0.0040	

<sup>a</sup> Sameluerar med 12369, 12489, 23467-PeCDF

<sup>c</sup> Sameluerar med 123489-HxCDF

<sup>b</sup> Sameluerar med 123689-HxCDF

*Kursiv stil* innebär mätvärdesspår, resultat med utökad mätosäkerhet upp till 75%

<b>Provet ankom:</b>	160121	<b>Typ av GC-kolonn:</b>	DB-5ms
<b>Lagringsbetingelser :</b>	Kyl	<b>Personer ansvariga för</b>	Maria Hjelt,
<b>Startdatum för</b>	160419	<b>upparbetning och analys:</b>	Per Liljelind
<b>upparbetn:</b>			
<b>Startdatum för analys:</b>	160609		



## Analysrapport klorerade dioxiner och furaner

**Vår provmärkning** : 3691:6  
**Er provmärkning** : Fältblank filter  
**Provtyp** : luftprov  
**Mätosäkerhet** :  $\pm 29 \%$  (95% konfidensintervall)

Kongen	pg/prov		Återfunnen <sup>13</sup> C IS (%)
	Konc.	WHO-TEQ(%)	
2378 TeCDD	ND(0.65)	17	91%
12378 PeCDD	ND(1.2)	31	91%
123478 HxCDD	ND(1.7)	4.6	88%
123678 HxCDD	ND(1.6)	4.3	92%
123789 HxCDD	ND(1.7)	4.5	91%
1234678 HpCDD	ND(1.2)	0.32	92%
OCDD	ND(1.5)	0.012	75%
2378 TeCDF	ND(0.50)	1.3	98%
12378 PeCDF	ND(1.3)	1.1	76%
23478 PeCDF <sup>a</sup>	ND(1.5)	12	82%
123478 HxCDF	ND(1.8)	4.7	89%
123678 HxCDF	ND(1.7)	4.5	96%
234678 HxCDF <sup>b</sup>	ND(2.0)	5.3	90%
123789 HxCDF <sup>c</sup>	ND(3.0)	8.1	100%
1234678 HpCDF	ND(1.9)	0.49	85%
1234789 HpCDF	ND(2.1)	0.56	100%
OCDF	ND(1.3)	0.010	82%
<b>Sum 2005 WHO-TEQ</b>	övre konc.	3.8	
	medelkonc.	1.9	
	nedre konc.	0	

<sup>a</sup> Sameluerar med 12369, 12489, 23467-PeCDF

<sup>c</sup> Sameluerar med 123489-HxCDF

<sup>b</sup> Sameluerar med 123689-HxCDF

<b>Provet ankom:</b>	160121	<b>Typ av GC-kolonn:</b>	DB-5ms
<b>Lagringsbetingelser :</b>	Kyl	<b>Personer ansvariga för</b>	Maria Hjelt,
<b>Startdatum för</b>	160419	<b>upparbetning och analys:</b>	Per Liljelind
<b>upparbetn:</b>			
<b>Startdatum för analys:</b>	160609		

## Analysrapport bromerade dioxiner och furaner

Vår provmärkning :3691:1  
Er provmärkning :2015-01-02-2015-03-30  
Provtyp :luftprov  
Mätosäkerhet :± 26 % (95% konfidensintervall)

Kongen	Koncentration pg/prov	Återfunnen <sup>13</sup> C IS (%)
2378-TBDF	6.2	142
12378-PeBDF	6.1	
23478-PeBDF	17	176
123478-HxBDF	86	210
1234678-HpBDF	810	166
OctaBDF	EA	
2378-TBDD	<2	120
12378-PeBDD	<3	88
123478+123678-HxBDD	<10	83
123789-HxBDD	<5	
1234678-HpBDD	<75	79
OctaBDD	EA	

EA = Ej analyserad

Provet ankom:	160121	Typ av GC-kolonn:	DB-5ms
Lagringsbetingelser :	Kyl	Personer ansvariga för	Maria Hjelt,
Startdatum för	160419	upparbetning och analys:	Per Liljelind
upparbetn:			
Startdatum för analys:	160609		

## Analysrapport bromerade dioxiner och furaner

**Vår provmärkning** :3691:2  
**Er provmärkning** :2015-03-30-2015-06-30  
**Provtyp** :luftprov  
**Mätosäkerhet** :± 26 % (95% konfidensintervall)

Kongen	Koncentration pg/prov	Återfunnen <sup>13</sup> C IS (%)
2378-TBDF	<2	138
12378-PeBDF	<3	
23478-PeBDF	3.3	184
123478-HxBDF	<5	197
1234678-HpBDF	<50	197
OctaBDF	EA	
2378-TBDD	<2	102
12378-PeBDD	<3	84
123478+123678-HxBDD	<10	81
123789-HxBDD	<5	
1234678-HpBDD	<75	82
OctaBDD	EA	

EA = Ej analyserad

<b>Provet ankom:</b>	160121	<b>Typ av GC-kolonn:</b>	DB-5ms
<b>Lagringsbetingelser :</b>	Kyl	<b>Personer ansvariga för</b>	Maria Hjelt,
<b>Startdatum för</b>	160419	<b>upparbetning och analys:</b>	Per Liljelind
<b>upparbetn:</b>			
<b>Startdatum för analys:</b>	160609		

## Analysrapport bromerade dioxiner och furaner

Vår provmärkning :3691:3  
Er provmärkning :2015-06-30-2015-10-02  
Provtyp :luftprov  
Mätosäkerhet :± 26 % (95% konfidensintervall)

Kongen	Koncentration pg/prov	Återfunnen <sup>13</sup> C IS (%)
2378-TBDF	<2	125
12378-PeBDF	<3	
23478-PeBDF	<3	164
123478-HxBDF	12	166
1234678-HpBDF	270	167
OctaBDF	EA	
2378-TBDD	<2	106
12378-PeBDD	<3	74
123478+123678-HxBDD	<10	74
123789-HxBDD	<5	
1234678-HpBDD	<75	70
OctaBDD	EA	

EA = Ej analyserad

Provet ankom:	160121	Typ av GC-kolonn:	DB-5ms
Lagringsbetingelser :	Kyl	Personer ansvariga för	Maria Hjelt,
Startdatum för	160419	upparbetning och analys:	Per Liljelind
upparbetn:			
Startdatum för analys:	160609		

## Analysrapport bromerade dioxiner och furaner

Vår provmärkning :3691:4  
Er provmärkning :2015-10-02-2016-01-04  
Provtyp :luftprov  
Mätosäkerhet :± 26 % (95% konfidensintervall)

Kongen	Koncentration pg/prov	Återfunnen <sup>13</sup> C IS (%)
2378-TBDF	5.5	116
12378-PeBDF	8.3	
23478-PeBDF	17	171
123478-HxBDF	110	184
1234678-HpBDF	970	159
OctaBDF	EA	
2378-TBDD	<2	94
12378-PeBDD	<3	77
123478+123678-HxBDD	<10	70
123789-HxBDD	<5	
1234678-HpBDD	<75	76
OctaBDD	EA	

EA = Ej analyserad

Provet ankom:	160121	Typ av GC-kolonn:	DB-5ms
Lagringsbetingelser :	Kyl	Personer ansvariga för	Maria Hjelt,
Startdatum för	160419	upparbetning och analys:	Per Liljelind
upparbetn:			
Startdatum för analys:	160609		

## Analysrapport bromerade dioxiner och furaner

Vår provmärkning :3691:5  
Er provmärkning :Fältblank XAD  
Provtyp :luftprov  
Mätosäkerhet :± 26 % (95% konfidensintervall)

Kongen	Koncentration pg/prov	Återfunnen <sup>13</sup> C IS (%)
2378-TBDF	<2	151
12378-PeBDF	<3	
23478-PeBDF	<3	193
123478-HxBDF	<5	211
1234678-HpBDF	<50	207
OctaBDF	EA	
2378-TBDD	<2	127
12378-PeBDD	<3	96
123478+123678-HxBDD	<10	93
123789-HxBDD	<5	
1234678-HpBDD	<75	86
OctaBDD	EA	

EA = Ej analyserad

Provet ankom:	160121	Typ av GC-kolonn:	DB-5ms
Lagringsbetingelser :	Kyl	Personer ansvariga för	Maria Hjelt,
Startdatum för	160419	upparbetning och analys:	Per Liljelind
upparbetn:			
Startdatum för analys:	160609		

## Analysrapport bromerade dioxiner och furaner

Vår provmärkning :3691:6  
Er provmärkning :Fältblank filter  
Provtyp :luftprov  
Mätosäkerhet :± 26 % (95% konfidensintervall)

Kongen	Koncentration pg/prov	Återfunnen <sup>13</sup> C IS (%)
2378-TBDF	<2	160
12378-PeBDF	<3	
23478-PeBDF	<3	221
123478-HxBDF	<5	249
1234678-HpBDF	100	209
OctaBDF	EA	
2378-TBDD	<2	132
12378-PeBDD	<3	96
123478+123678-HxBDD	<10	92
123789-HxBDD	<5	
1234678-HpBDD	<75	87
OctaBDD	EA	

EA = Ej analyserad.

Provet ankom:	160121	Typ av GC-kolonn:	DB-5ms
Lagringsbetingelser :	Kyl	Personer ansvariga för	Maria Hjelt,
Startdatum för	160419	upparbetning och analys:	Per Liljelind
upparbetn:			
Startdatum för analys:	160609		



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