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**Table 1. Detection in wastewater treatment, sludge and matrix from impacted sites and from manufacture/recycling sites**

| Matrix | Country/ Region | Year | Study site<br>Type of location | Concentration | | | Comments | Reference |
|---|---|---|---|---|---|---|---|---|
| **Wastewater treatment, sludge, impacted sites and from manufacture etc** | | | | ***syn*** | ***anti*** | ***tot*DP** | | |
| Wastewater | China | 2010-2011 | WWTP, Shanghai | | | 50-1400 pg/L | | Xiang et al., 2014 |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| Soil | China | 2009 | E-waste recycling site | | | 0.17-1990 ng/g dw | | Xiao et al., 2013 |
| Soil | China | 2009 | Near manufacturing plant | | | 0.83-1200 | | Wang et al., 2010b |
| Soil | China | 2009 | Manufacturing facility in Huai'an | | | 5.11-13400 ng/g dw | | Wang et al., 2010a |
| Soil | China | 2011 | Manufacturing facility in Huai'an | | | 0.50–2315 | | Zhang et al., 2015 |
| Soil | China | - | E-waste disposal area in Guiyu | 0.14–38 ng/g | 0.42–107 ng/g | 0.57–146 ng/g | | Xu et al., 2017 |
| Soil | China | | E-waste recycling site | 1081 | 2246 | 3327 ng/g | | Yu et al., 2010 |
| Soil | China | | Areas surrounding the e-waste recycling sites | n.d. - 12.2 | n.d. - 36.3 | n.d. - 47.4 ng/g | | Yu et al., 2010 |
| Soil | China | | Industrial areas | n.d. - 1.18 | 0.03 - 3.47 | 0.03 - 4.65 ng/g | | Yu et al., 2010 |
| Soil | China | | Manufacturing areas | | | 0.50–2,315 pg/g | | Zhang et al., 2015 |
| Sediment | Lake Ontario | 2004 | Near manufacturing plant | | | <310 ng/g dw | | Qiu et al.,2007 |

| Matrix | Country/ Region | Year | Study site<br>Type of location | Concentration | | | Comments | Reference |
|---|---|---|---|---|---|---|---|---|
| **Wastewater treatment, sludge, impacted sites and from manufacture etc** | | | | ***syn*** | ***anti*** | ***tot*DP** | | |
| Sediment core | Lakes Erie | 1997-1998 | Near manufacturing plant | | | 0.061-8.62 | | Sverko et al., 2008 |
| Sediment core | Lake Ontario | 1997-1998 | Near manufacturing plant | | | 2.23-586 | | Sverko et al., 2008 |
| Surficial sediments | Great Lakes, Canadian site | 2002-2006 | Near manufacturing plant | | | 0.035-310 | | Shen et al., 2011b |
| Suspended sediment | Niagara river | 1980-2007 | Near manufacturing plant | | | 2.5-62 | | Shen et al., 2011a |
| Sediment core | Lake Ontario | | Near manufacturing plant | | | 0.061-160 | | Shen et al., 2011a |
| Surficial sediment core | Lake Ontario | 2007 | Near manufacturing plant | | | 73-140 | | Yang et al., 2011 |
| Sediment core | Lake Ontario | 2006-2007 | Near manufacturing plant | | | 0.85-96 | | Shen et al., 2010 |
| Sediment | China | | Manufacturing facility in Huai'an | | | 1.86-8.00 | | Wang et al., 2010a |
| Sediment | China | 2009 | e-waste recycling site | 520-1630 ng/g | 1860-6630 ng/g | | | Zhang et al., 2011b |
| Riverine surface sediments | China | 2013 | e-waste recycling region in Taizhou | 27 – 14280 pg/g dw | 81 – 13410 pg/g dw | 108 – 55270 pg/g dw | *anti*-$Cl_{10}$: nd - 2580<br>*anti*-$Cl_{11}$: 2 - 580 | Zhou et al., 2017 |
| Suspended sediment | China | - | e-waste recycling site | 13130 ± 2885 ng/g | 65660 ± 11440 ng/g | | ng/g OC | Wu et al., 2010 |
| Surficial sediment | China | - | e-waste recycling site | 21820 ± 2160 ng/g | 55320 ± 7140 ng/g | | | Wu et al., 2010 |

| Matrix | Country/ Region | Year | Study site<br>Type of location | Concentration | | | Comments | Reference |
|---|---|---|---|---|---|---|---|---|
| **Wastewater treatment, sludge, impacted sites and from manufacture etc** | | | | ***syn*** | ***anti*** | ***tot*DP** | | |
| Sediment | China | | Manufacturing areas | | | 0.32–20.5 ng/g dw | | Zhang et al., 2015 |
| Sewage sludge | Norway | 2017 | WWTP | 2.1 ng/g | 7.4 ng/g | | | Norwegian Environment Agency, 2018b |
| Sewage sludge | Norway | 2018 | WWTP | 2.5 ng/g | 11.8 ng/g | | | Norwegian Environment Agency, 2019a |
| Sewage sludge | Spain | | WWTP | | | 2.58-18.8 ng/g d.w. | | Barón et al., 2012 |
| Sludge | Spain | 2010 | Ebro and Llobregat river basins, | | | <0.06-18.8 | | Barón et al., 2014b |
| Sewage sludge, biosolids | USA | 2006-2010 | Municipal, North Carolina | 2-24 | 5-29 | | | Davis et al., 2012 |
| Sewage sludge | Spain | 2006 | WWTP | | | 2.45-93.8 ng/g d.w. | | de la Torre et al., 2011a |
| Sludge | China | 2013-2014 | Sewage treatment plants (STP) | 8.6 - 16 | 7.2 – 19.2 | | | Wu et al., 2017 |
| | | | | | | | | |
| Air | Canada | 2017-2018 | e-waste recycling site, small facility | 2–5.8 ng/m3 | 2.3–5.4 ng/m3 | 4.4–11 ng/m3 | | Gravel et al., 2019 |
| Air | Canada | 2017-2018 | e-waste recycling site, medium facility | 4.7–9.3 ng/m3 | 7.3–15 ng/m3 | 12–24 ng/m3 | | Gravel et al., 2019 |
| Air | Canada | 2017-2018 | e-waste recycling site, large facility | 12–18 ng/m3 | 22–34 ng/m3 | 34–53 ng/m3 | | Gravel et al., 2019 |

**Table 2. Overview over available bioaccumulation data**[1]

| Species (tissue) | Region/Exposure | Tissue | BAF/BCF | BMF | | | TMF | | | Comments and | References |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Aquatic organisms/food webs** | | | **L/kg** | ***syn*** | ***anti*** | ***tot*DP** | ***syn*** | ***anti*** | ***tot*DP** | **Benchmark BMF/TMF** | |
| Fish/zoo plankton | Canada/Field | whole | | <0.1-0.6 | 0.8-11 | | | | | | Tomy et al., 2007 |
| Fish/diporeia (shrimp-like) | Canada/Field | whole | | 0.1-12 | 0.1-11 | | | | | | Tomy et al., 2007 |
| Fish/zoo plankton | Canada/Field | whole | | | | | 1.3 | 1.1 | | PBDEs | Kurt-Karakus et al., 2019 |
| Fish/invertebrate | South China/Field | Various | | | | | 11.3 | 6.5 | 10.2 | PBDEs and PCBs | Wu et al., 2010 |
| Fish/invertebrate (seven species) | Huai'an China/Field | whole | | | | | 3.1 | 1.9 | 2.2 | DPMA, anti-Cl11-DP and anti-Cl10-DP | Wang et al., 2015 |
| Fish (various)/crab | South China/Field | various | | | | 1.3-11.8 | | | 2.3* | | Sun et al., 2015 |
| Food web (fish, octopus, crab) | South China/Field | muscle | | | | 2.3-7.1 | | | | PBDEs, DDT and PCBs | Sun et al., 2017 |
| Fish diet study | | whole - liver | | 5.2 | 1.9 | | | | | | Tomy et al., 2008 |
| Fish diet study | Laboratory | serum | | 1.06 | 1.23 | | | | | | Tang et al., 2018 |
| Seal/algae (total nine species) | Antarctica | various | | | | | 2.9 | 3.3 | 3.0 | PCBs | Na et al., 2017 |
| Skua (bird)/penguins | Antarctica | muscle (pectoralis) | | | | | 18.9 | 21.5 | | | Kim et al., 2015 |
| Carp | Laboratory | muscle | BCF *syn*-DP 5700<br>BCF *anti*-DP 9300 | | | | | | | | Wang et al., 2019 |
| Terrestrial organisms/food webs | | | | | | | | | | | |

| Species (tissue) | Region/Exposure | Tissue | BAF/BCF | BMF | | | TMF | | | Comments and | References |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Frog/insect | South China/Field | muscle/whole | | 2.7 | 1.8 | 2.1 | | | | BMFs for PBDEs and anti-Cl11-DP detected | Wu et al., 2018 |
| Owl/sparrow | Beijing, China | muscle | | 12 | 6.8 | 10 | | | | PBDEs, PCBs, HBCD, ppDDE | Yu et al., 2013 |
| Owl/brown rat | Beijing, China | muscle | | 2.4 | 1.9 | 2 | | | | PBDEs, PCBs, HBCD, ppDDE | Yu et al., 2013 |
| Sparrow/common kestrel | Beijing, China | muscle | | 0.31 | 0.35 | 0.32 | | | | PBDEs, PCBs, HBCD, ppDDE | Yu et al., 2013 |
| Brown rat/common kestrel | Beijing, China | muscle | | 0.06 | 0.10 | 0.06 | | | | PBDEs, PCBs, HBCD, ppDDE | Yu et al., 2013 |
| Apple snail/rice plant | South China/Field | | | 3.1 | 2.3 | | | | | PBDEs | She et al., 2013 |

*Non-significant

[└]Definitions:

Bioconcentrationfactor (BCF; point) – describes uptake and accumula1on of chemical from water only.

Bioaccumulation factor (BAF; point) – describes uptake and accumula1on of chemical from all sources (water, sediment, diet, etc.) relative to amount of chemical (exposure) in water.

Biota-sediment accumulation factor (BSAF; point) – describes uptake and accumula1on of chemical from all sources relative to amount of chemical (exposure) in sediment.

Biomagnification factor (BMF; slope) – describes rate of change of chemical concentration in organisms separated by a single trophic level step ($\Delta TL=1$) on a food chain.

Trophic magnification factor (TMF; slope) – describes rate of change of chemical concentra1on in organisms that occupy successively higher trophic levels ($\Delta TL>1$) in a food web.

**Table 3:** Abiotic monitoring data for Dechlorane Plus in remote locations (adopted from ECHA 2017d) [TO BE COMPLETED]

| Compartment | Location | Findings | Reference |
|---|---|---|---|
| **Atmosphere** | Two remote research stations: one in Canadian high Arctic (Alert) and the other in the Tibetan Plateau (Nam Co) | Sampling dates not explicitly stated for Alert (but appear to be in the period 2006 to 2007). Monthly-integrated samples were collected between October 2006 and February 2008 at Nam Co. Detected in 11 out of 14 samples at Alert with total DP ranging from <0.05 pg/m3 to 2.1 pg/m3, primarily associated with particles. Not detected in pre-screening at Nam Co, which is suggested by the study authors to be due to fewer particulates reaching the station. | Xiao *et al*. (2012) |
| **Atmosphere** | Transects in East Greenland Sea, and northern and southern Atlantic Ocean | Sampling took place during August – September 2009 (Greenland) and November – December 2008 (Atlantic), 10 samples from each transect, with sampling over 2-6 days at 15 m a.s.l. DP was detected in all air samples, at concentrations of 0.05 – 4 pg/m3. DP was mainly detected in the particulate phase. In the Atlantic, the highest concentration was observed in the English Channel originating from continental air passing Western Europe. The fractional abundance of syn-DP increased with decreasing northern latitude from 0.37 to ca. 0.67, showing a stereoselective depletion of anti-DP (thought to be caused by UV sunlight). | Möller *et al*. (2010) |
| **Atmosphere** | Transect from East China Sea to Arctic | 17 air samples taken between June and September 2010. Each sample was collected over 1-2 days (height not specified). DP was detected in all samples in the range 0.01 – 1.4 pg/m3 (as total DP), mainly in the particulate phase. Includes remote areas, but not exclusively. | Möller *et al*. (2011) |
| **Atmosphere** | Transect in Indian, Pacific and Southern Oceans from southeast Asia to Antarctica | Sampling took place during November 2010 – March 2011 (n=20). Each sample was collected over 1-2 days at 20 m a.s.l. DP was detected in all samples as follows:<br><br>Pacific Ocean: 1.7-11 pg/m3 (total DP)<br><br>Indian Ocean: 0.26 – 2.1 pg/m3 (total DP)<br><br>Southern Ocean: 0.31 pg/m3 (total DP) | Möller *et al*. (2012) |
| **Atmosphere** | Station Nord, Northeast Greenland | Detected in 46 % of air samples collected weekly throughout 2012. Syn-DP concentration: mean 2.32 pg/m3 (range <1 - 9.0 pg/m3). Anti-DP concentration: mean 5.24 pg/m3 (range <1- 33.1 pg/m3). | Vorkamp *et al*. (2015) |

| | | | |
|---|---|---|---|
| **Atmosphere** | Arctic (78.22°N 15. 65°E)<br><br>Longyearbyen is a coal mining community with 2 100 residents and so a local source of Dechlorane Plus (e.g. building and pipe insulation) cannot be ruled out. | Samples were collected from September 2012 to May 2013 (a total of 34 samples, each collected over 48 hours). The samples represent the atmospheric particulate fraction collected on quartz fibre filters (2.2 µm cut-off).<br><br>Total DP concentration was 0.05-5 pg/m3.<br><br>Anti-DP was detectable in 91 % of the samples with a mean (± standard error) of 1.1 (±0.19) pg/m3.<br><br>Syn-DP was detectable in 91 % of the samples with a mean (± standard error) of 0.29 (±0.04) pg/m3.<br><br>The fanti ranged from 0.43 to 0.9 with a mean value of 0.75, which is reasonably consistent with that in commercial Dechlorane Plus products. | Salamova *et al*. (2014) |
| **Atmosphere** | Råö (Swedish west coast), Pallas (Northern Finland), Aspvreten (Swedish east coast, 70 km SW of Stockholm)<br><br>[These represent 'background' sites.] | Samples were apparently collected in May, July and November 2009 and January 2010. DP concentrations were:<br><br>Råö: 0.18 – 0.52 pg/m3 (n=4)<br><br>Pallas: 0.016 – 0.047 pg/m3 (n=2; January and July only)<br><br>Aspvreten: 0.12 - 0.23 pg/m3 (n=3; January, July and November)<br><br>Deposition fluxes were estimated from the monthly average data as follows:<br><br>Råö: 0.11 – 0.34 ng/m2/d<br><br>Pallas: 0.017 – 0.025 ng/m2/d<br><br>Aspvreten: 0.15 - 0.39 ng/m2/d | Kaj et al. (2010) |
| **Atmosphere** | Review of Arctic data | Does not cite articles beyond the ones already summarised here | Vorkamp *et al*. (2014) |
| **Atmosphere** | Northern Sweden | Bimonthly bulk atmospheric deposition samples were taken for one year from October 2009 to November 2010. DP was detected on all seven sampling occasions at Abisko in the Arctic (68°20'N, 9°03'E) at a maximum amount of 5.7 ng per sample (total isomers). DP was detected on three of five sampling occasions at Krycklan in the sub-Arctic | Newton *et al*. (2014) |

| | | | |
|---|---|---|---|
| | | (64°14'N, 19°46'E; located approximately 60 km northwest of the city of Umeå) at a maximum amount of 0.16 ng per sample (total isomers).<br><br>The average (±standard deviation) of the monthly deposition flux for total DP was calculated to be 22±2.1 ng/m2/month at Abisko and 1.1±0.52 ng/m2/month at Krycklan. It is interesting to note that the higher flux was found at the more remote site. Newton et al. (2014) considered the air-parcel back trajectories at both sites. Both sites receive airflow from the west off the Norwegian and Barents Seas, and from the eastern and southern Baltic countries. However, Abisco is around 100 km from the Norwegian coast and receives a higher proportion of its air from the ocean than the continent, whereas a higher proportion of the air at Krycklan comes from the south and east and the air from the ocean passes over the land mass of Norway and Sweden. Thus the differences in fluxes at the two sites may reflect differences in emission sources.<br><br>The fraction of the anti- isomer was lower at the Arctic site (mean 0.25) than the sub-Arctic site (mean 0.62), suggesting isomer-selective degradation or isomerization during long range transport to the more remote site. The fanti- at the sub-Arctic site was similar to that in commercial products, and may indicate proximity to a local source. | |
| **Atmosphere** | Entebbe, Lake Victoria, Uganda | Weekly air sampling between October 2008 and July 2010. DP was not detected in 9 samples from 2008. In the 30 samples from 2009, syn-DP was detected in 17 % of samples (arithmetic mean: 0.21 pg/m3) and anti-DP in 10% of samples (arithmetic mean: 0.10 pg/m3). The geometric mean was below the detection limit for both isomers. In 17 samples from 2010, syn-DP was detected in 18 % of samples (arithmetic mean: 0.46 pg/m3; geometric mean 0.05 pg/m3) and anti-DP in 76 % of samples (arithmetic mean: 0.33 pg/m3; geometric mean 0.18 pg/m3). The paper notes that recycling of electronic equipment may be the source of the contamination. | Arinaitwe *et al*. (2014) |
| **Atmosphere** | All continents except Antarctica | Samples collected July – September 2005 (possibly also 2006) for a Global Atmospheric Passive Sampler (GAPS) study (25 sites, number of samples not stated). Reported concentrations ranged from 'not detected' to 348 pg/m3, the highest level being for Cape Grim, Tasmania where population density is very low. It was also detected in north Alaska and Svalbard. | Sverko *et al*. (2010a) [ABST] |

| | | | |
|---|---|---|---|
| **Seawater** | Transects of sampling in East Greenland Sea, northern and southern Atlantic Ocean | Sampling took place during August – September 2009 (Greenland) and November – December 2008 (Atlantic). 10 samples from each transect. Concentrations in sea water were <detection limit – 1.3 pg/L, and DP was mainly detected in the particulate phase. Includes remote areas, but not exclusively. | Möller *et al*. (2010) |
| **Seawater** | Transect of sampling from East China Sea to Arctic | 18 sea water samples taken between June 2010 and September 2010, with each sample collected over 12-24 h. Seawater concentrations ranged between 0.006 – 0.4 pg/L. Includes remote areas, but not exclusively. | Möller *et al*. (2011) |
| **Seawater, sediment, soil and air** | Ny-Ålesund, Svalbard (78°55′N, 11°56′E). | Samples of soil, moss and dung were collected simultaneously (see Appendix 4 for the moss and dung results). The mean (and range) of concentrations in the soil samples was 0.042 (0.012-0.105) µg/kg dw) for anti-DP and 0.284 (0.094-1.01) µg/kg dw for syn-DP. The fanti in the soil samples was 0.18.<br><br>Sediment and seawater samples were also taken at King's bay. The mean (and range) measured concentrations were 32 (85-648) pg/L and 61 (22-116) pg/L for anti-DP and syn-DP, respectively, in seawater; and 0.073 (0.023-0.228) µg/kg dw and 0.270 (0.085-0.648) µg/kg dw for anti-DP and syn-DP, respectively, in sediment. The fanti was 0.36 in seawater and 0.21 in sediment.<br><br>Na *et al.* (2015) considered that the low fanti values found in water, sediment, soil (and also moss; see Appendix 4) may reflect degradation of anti-DP during long-range transport, possibly by UV. | Na *et al.* (2015) |
| **Sediment** | Kongsfjorden, Svalbard, Norwegian Arctic | 27 samples of surficial sediment taken in July 2009. Syn-DP and anti-DP were detected in 78 % and 94 % of samples, respectively. Syn-DP ranged between n.d. - 5.4 pg/g dw (mean: 1.4 ± 1.5 pg/g dw). Anti-DP ranged between n.d. - 15.9 pg/g dw (mean: 4.5 ± 4.3 pg/g dw). No clear spatial trend between the outer and inner fjord. The paper notes that it is plausible that both glacial runoff and oceanic currents play a role in introducing DP to the fjord sediments. The relatively low fractional abundance of the syn-DP isomer indicates the long-range transport of this chemical to this Arctic site. | Ma *et al*. (2015) |

**Table 4.** Atmospheric concentrations (in pg m$^{-3}$, sum of gaseous and particulate phases) of PBDEs, HBB, PBT, DPTE and DP over the global oceans and their marginal seas (na = Not Analyzed, nd = Not Detected) as shown in Möller et al. 2012.

| | year[a] | BDE-47 | BDE-209 | ΣPBDEs | HBB | PBT | DPTE | DP | ref |
|---|---|---|---|---|---|---|---|---|---|
| Atlantic Ocean | 2008 | 0.57−8.3 | na | 0.86−6.4 | na | na | na | na | ref49 |
| Atlantic Ocean | 2008 | 0.18−2.3 | na | 0.43−3.3 | 0.10−11 | 0.01−0.05 | 0.10−2.3 | 0.05−1.6 | ref17,20 |
| Atlantic Ocean (North Sea) | 2010 | 0.10−0.79 | nd−9.4 | 0.31−10.7 | 0.09−6.3 | nd−0.24 | nd−2.5 | 0.13−22 | ref23 |
| Pacific Ocean | 2010 | 0.04−0.11 | nd−2.0 | 0.22−2.3 | 0.10−2.5 | 0.12−0.64 | 0.18−0.41 | 0.01−0.86 | ref18 |
| Pacific Ocean[b] | 2003 | 0.88−17 | <0.5−27 | 1.4−37 | na | na | na | na | ref22 |
| Pacific Ocean (East Asian Seas) | 2010 | 0.07−0.76 | 0.13−3.9 | 0.31−8.1 | 0.26−5.9 | 0.36−4.53 | 0.26−5.9 | 0.52−0.75 | ref18 |
| Pacific Ocean (East Asian Seas)[b] | 2003 | <0.16−112 | <0.50−29 | 2.3−199 | na | na | na | na | ref22 |
| Pacific Ocean (East and South China Seas) | 2008 | 0.41−13 | na | 2.9−29 | na | na | na | na | ref49 |
| Pacific Ocean (East Indian Archipelago and Philippine Sea) | 2010/11 | 0.14−0.32 | nd−4.0 | 0.14−4.6 | 3.7−19 | 0.71−2.2 | 0.44−2.3 | 1.7−11 | this study |
| Indian Ocean | 2008 | 0.57−8.3 | na | 1.15−13 | na | na | na | na | ref49 |
| Indian Ocean | 2004/05 | <3.4−13 | <0.6 | 1.5−16 | na | na | na | na | ref39 |
| Indian Ocean | 2010/11 | nd−0.49 | nd−6.5 | nd−6.6 | 0.15−26 | nd−2.8 | nd−1.1 | 0.26−2.1 | this study |
| Arctic Ocean | 2010 | 0.03−0.04 | nd−4.0 | 0.07−4.1 | 0.16−0.42 | 0.22−0.79 | 0.10−0.19 | 0.05−0.44 | ref18 |
| Arctic Ocean[b] | 2003 | <0.16-31 | <0.50−41 | <2.58−61 | na | na | na | na | ref22 |
| Arctic Ocean (Greenland Sea) | 2009 | 0.06−0.95 | nd−0.07 | 0.09−1.8 | 0.08−0.66 | nd−0.02 | 0.01−1.7 | 0.02−4.2 | ref17,19 |
| Southern Ocean | 2008 | 0.58 | na | 0.78 | 0.32 | 0.02 | 0.04 | 0.07 | ref17,20 |
| Southern Ocean | 2010/11 | 0.08 | nd | 0.13 | 0.12 | nd | nd | 0.31 | this study |

[a]Year of sampling. [b]Only aerosols.

**Table 5.** Concentrations of *syn*- and *anti*-DP in air samples from Arctic stations, as presented in Vorkamp et al. 2019.

| Location | Year | Mean ΣDP concentration (pg/m$^3$) | Maximum ΣDP concentration (pg/m$^3$) | Reference |
|---|---|---|---|---|
| Villum Research Station | 2014-2016 | 4.2 | 31.7 | This study (all samples) |
| Villum Research Station | 2014 | 0.64 | 5.3 | This study, monthly samples |
| Villum Research Station | 2012 | 6.7 | 41 | Vorkamp et al. (2015) |
| Pallas, Finland | 2013/2014 | 0.039 | 0.061 | Haglund et al. (2016) |
| Little Fox Lake, Yukon, Canada | 2011-2014 | ~ 0.25 | ~ 1.8 | Yu et al. (2015) |
| Longyearbyen, Svalbard * | 2012/2013 | 1.2 | 5.0 | Salamova et al. (2014) |
| Alert, Canada | 2007 | ~ 0.75 | 2.1 | Xiao et al. (2012) |

* Particle phase only. DP is mainly associated with particles (Hoh et al., 2006).

**Table 6.** Concentrations (ng/g lipid weight) and detection frequencies (DF) of syn- and anti-dechlorane plus (DP) in biota samples from Greenland (Vorkamp et al. 2019). Lipids (%) describes mean lipid content of the samples. Concentrations < LOQ were set to 0 in the calculations of means.

| Species | | syn-DP | | | anti-DP | | |
|---|---|---|---|---|---|---|---|
| | Lipids (%) | DF (%) | Mean | Range | DF (%) | Mean | Range |
| Arctic char | 0.69 | 0 | <0.13 | <0.13 | 50 | 0.047 | <0.030-0.19 |
| Glaucous gull (Thule) | 5.3 | 100 | 0.22 | 0.076-0.35 | 100 | 0.89 | 0.34-1.2 |
| Ringed seal (Thule) | 92 | 0 | <0.018 | <0.018 | 0 | <0.017 | <0.017 |
| Harp seal | 95 | 25 | 0.008 [a] | <0.018-0.032 | 25 | 0.014 [a] | <0.017-0.058 |
| Hooded seal | 92 | 50 | 0.013 [a] | <0.017-0.033 | 50 | 0.019 | <0.017-0.045 |
| Bearded seal | 88 | 20 | 0.004 [a] | <0.017-0.019 | 20 | 0.009 [a] | <0.015-0.045 |
| Narwhal | 90 | 0 | <0.065 | <0.065 | 12.5 | 0.012 [a] | <0.039-0.096 |
| Killer whale | 98 | 9.1 | 0.040 [a] | <0.038-0.44 | 18.2 | 0.19 | <0.037-2.1 |
| Glaucous gull (East) | 5.3 | 87.5 | 0.24 | <0.55 [b]; 0.079-0.54 | 100 | 0.93 | 0.39-2.1 |
| Ringed seal (East) | 90.6 | 0 | <0.014 | <0.014 | 50 [c] | 0.076 | <0.013-0.17 |

[a] value near or below detection limits; [b] very low sample intake (0.31 g); [c] detected in two out of four samples, in the fifth sample the peak could not be integrated.

## Table 7. Measured concentrations in biota associated with the aquatic environment [TO BE COMPLETED]

| Species | Tissue | Sample location and date | Limit of detection (LoD), µg/kg ww | Measured concentration | Comment | Reference |
|---|---|---|---|---|---|---|
| **INVERTEBRATES** | | | | | | |
| Mussel<br>(species not specified) | Soft parts | Niagara River area, Canada (it appears that two different locations were involved, with one mussel representing each site); date of sampling not stated | - | Site 1 (n=1)<br>Total isomers: ~4 µg/kg ww<br>Anti-DP: ~2 µg/kg ww<br>Syn-DP: ~2 µg/kg ww<br>Site 2 (n=1)<br>Total isomers: ~1.8 µg/kg ww<br>Anti-DP: ~1 µg/kg ww<br>Syn-DP: ~0.8 µg/kg ww | Analysis by GC-HRMS.<br>Not known if mussels were depurated prior to analysis.<br>Values read from a graph. | Kolic *et al*. (2009) |
| Blue Mussel<br>(Mytilus edulis) | Soft parts | Receiving water from Åse WWTP, Åsefjorden, Norway (sampling date not stated).<br>Fossá river estuary, Hvalfjörður, Iceland in November 2011. | Not explicitly stated, but presumably 0.003/4 for both isomers | Norwegian (urban) site:<br>Total isomers: 0.035-0.042 µg/kg ww<br>Anti-DP: 0.018-0.019 µg/kg ww<br>Syn-DP: 0.017- 0.023 µg/kg ww<br>Icelandic site: Neither isomer was above the LoD (no. of samples not stated). | Analysis by GC-MS.<br>Not known if mussels were depurated prior to analysis.<br>The Icelandic site is remote from human activity. | Schlabach *et al*. (2011) |
| **FISH** | | | | | | |
| Barbel (*Barbus barbus*) (n not stated)<br>Wels Catfish (*Silurus glanis*) (n not stated)<br>Common Carp (*Cyprinus carpio*) (n not stated) | Not stated | Ebro river basin, Spain (year not stated) | Anti-DP: 0.0023<br>Syn-DP: 0.0055<br>(µg/kg lw) | Total isomer concentration:<br>Median: 0.88 µg/kg lw<br>Range: <LoD – 2.24 µg/kg lw | Analysis by GC-NCI-MS-MS.<br>Presumably a sub-set of the data reported by Santín *et al*. (2013). | Barón *et al*. (2012) |
| Fish (various species)<br>(n=48) | Whole body | Llobregat, Ebro, Júcar and Guadalquivir river basins, Spain; 2010 | Anti-DP: 0.0023<br>Syn-DP: 0.0055<br>(µg/kg lw) | Concentration ranges (total isomers), µg/kg lw:<br>Llobregat river basin: 0.57–4.86<br>Ebro river basin: 0.11–1.28<br>Júcar river basin: <LoD-0.59<br>Guadalquivir river basin: 0.06–1.91 | Analysis by GC-MS.<br>The study included four Wels Catfish (*Silurus glanis*) caught in the Ebro river basin. | Santín *et al*. (2013) |
| Lake Trout (*Salvelinus namaycush*)<br>Whitefish (*Coregonus clupeaformis*) | Dorsal muscle | Lake Trout from Lake Superior in 2002 (n=3), Lake Huron in 2001 (n=5) and Lake Ontario in 1998 and 1999 (n=5), Canada.<br>Whitefish from Lake Erie in 2002 (n=5) and Lake Ontario in 2000 (n=5). | - | Detected in all samples in the range 0.061 – 2.600 µg/kg lw (total isomers)<br>Fish from Lake Ontario had higher concentrations compared to those from the other lakes. | Analysis by GC-HRMS.<br>Most fish samples had fanti values below the highest value of technical products (no difference was observed between the two fish species). | Shen *et al*. (2010) |

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| Walleye (*Stizostedion vitreum)* | ? | Lake Erie, USA; 1980, 1984, 1990, 1992, 1994, 1996, and 2000. Except for 1980 and 1984, there were three samples in each sampling year. | - | Range: 0.14-0.91 µg/kg lw | Analysis by GC-MS. | Hoh *et al*. (2006)<br><br>Houde *et al*. (2014) |
| Yellow Perch (*Perca flavescens*) (n = 29) | Whole body | Lake Erie, USA; 1980, 1984, 1990, 1992, 1994, 1996, and 2000. Except for 1980 and 1984, there were three samples in each sampling year. | Anti-DP: 0.05<br>Syn-DP: 0.12<br>(LoQ, µg/kg lw) | Not detected in any sample | Analysis by GC-MS. | Hoh *et al*. (2006)<br><br>Houde *et al*. (2014) |
| Northern Pike (*Esox lucius*) (n=11) | Liver | Lake Erie, USA; 1980, 1984, 1990, 1992, 1994, 1996, and 2000. Except for 1980 and 1984, there were three samples in each sampling year. | Anti-DP: 0.05<br>Syn-DP: 0.12<br>(LoQ, µg/kg lw) | Detected in 45 % of samples.<br>Range: not detected to 9.1 (syn-) or 2 (anti-) µg/kg lw | Analysis by GC-MS. | Hoh *et al*. (2006)<br><br>Houde *et al*. (2014) |
| Muskellunge (*Esox muskellunge*) (n=10) | Liver | Lake Erie, USA; 1980, 1984, 1990, 1992, 1994, 1996, and 2000. Except for 1980 and 1984, there were three samples in each sampling year. | Anti-DP: 0.05<br>Syn-DP: 0.12<br>(LoQ, µg/kg lw) | Detected in at least 90% of samples. Mean concentration (total isomers):<br>6.2 ± 3.6 µg/kg lw (one fish contained 37.4 µg/kg lw) | Analysis by GC-MS.<br><br>Most of the Muskelunge samples were >7 years old. | Hoh *et al*. (2006)<br><br>Houde *et al*. (2014) |
| Lake Trout (*Salvelinus namaycush*) (n=5 per year) | Whole body | Lake Ontario (north of Main Duck Island), Canada; 1979, 1983, 1988, 1993, 1998 & 2004 | 0.01 | Mean per year (total isomers):<br>0.31±0.07 to 0.85±0.20 µg/kg ww<br>[2.3±0.6 to 7.2±1.3 µg/kg lw] | Analysis by GC-MS.<br>Sampled fish were four to five years old.<br>Stable isotope analysis showed that trophic status and food sources were highly variable over time. | Ismail *et al*. (2009) |
| European Eel (*Anguilla anguilla*) | Whole body or muscle | Glass eels (n=100, split into 10 samples) collected from the French Atlantic coast; date not stated<br>Elvers (n=30), yellow (n=30) and silver eels (n=12) collected from Germany (River Vidå, River Elbe and Rivers Elbe and Rhine, respectively); date not stated | Anti-DP: 0.017,<br>Syn-DP: 0.0053 | Detected in all life stages. Total isomer concentrations were:<br>Glass eels: <0.02 – 0.32 µg/kg ww [<LoD – 31.8 µg/kg lw]<br>Elvers: <0.02 – 0.46 µg/kg ww [<LoD – 33.8 µg/kg lw]<br>Yellow eels: 0.013–0.50 µg/kg ww [0.14±0.008 µg/kg lw]<br>Silver eels: 0.017–0.38 µg/kg ww [0.17±0.19 µg/kg lw] | Analysis by GC-MS.<br>Levels were similar to American Eels, and probably reflect diffuse exposure.<br>The isomer ratio changes over the life cycle. The syn- isomer predominates (>80%) in glass, elvers and yellow eels, but its contribution drops to 40% in silver (fully adult) eels that have stopped feeding. | Sühring *et al*. (2013 and 2014) |
| American Eel<br>(Anguilla rostrata) | Whole body or muscle | Glass eels (n=37, pooled into three samples) from | Anti-DP: 0.017<br>Syn-DP: 0.0053 | Detected in all life stages. Total isomer concentrations were: | Analysis by GC-MS. | Sühring *et al*. (2014) & Byer *et al*. (2013) |

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| | | Baie des Sables, Matane, Quebec, Canada; 2007 and 2008<br>Young yellow eels (n=10) from the Saint Lawrence River, Canada; 2007 and 2008<br>Yellow eels (n=15, muscle) from Lake Ontario and the upper Saint Lawrence River, Canada; 2007 and 2008<br>Silver eels from Lake Ontario, Canada; 2007 and 2008 | | Glass eels: <0.02 µg/kg ww<br>Young yellow eels: 0.10–0.69 µg/kg ww<br>[1.7 ± 0.92 µg/kg lw]<br>Yellow eels: 0.19 ± 0.086 to 0.29 ± 0.20 µg/kg ww<br>[0.90 ± 0.41 to 0.17±0.19 µg/kg lw]<br>Silver eels: 0.067 ± 0.048 µg/kg lw<br>DPMA was detected in yellow and silver eels from the same area. | Levels were similar to European Eels, and probably reflect point source as well as diffuse exposure.<br>The isomer ratio changes over the life cycle. The syn- isomer predominates (>70%) in yellow eels, but its contribution drops to 44 % in silver (fully adult) eels that have stopped feeding. | |
| Perch<br>(Perca fluviatilis) | Muscle | One composite sample from Helsinki (Old City Bay) and five composite samples from Pyhäjärvi, Tampere. Finland (6–10 individuals per composite) (sampling date not stated).<br>Two locations (Riddarfjärden and Stora Essingen) at Lake Mälaren, Stockholm, Sweden (sampling date not stated). | Anti-DP: 0.001-0.003<br>Syn-DP: 0.002- 0.004 | Finnish sites:<br>Anti-DP: 0.0011 & 0.0030 µg/kg ww in two composite samples, all others below LoD<br>Syn-DP: 0.0038 µg/kg ww in one composite sample, all others below LoD.<br>Swedish site: Neither isomer was above the LoD (no. of samples not stated). | Analysis by GC-MS.<br>The sites are in urban areas. | Schlabach *et al*. (2011) |
| Arctic Char (*Salvelinus alpinus*) | Muscle | á Mýranar lake, Faroe Islands (sampling date not stated). | Not explicitly stated, but presumably 0.003/4 for both isomers | 12 fish analysed as a pooled sample. Neither isomer was above the LoD. | Analysis by GC-MS.<br>Site is remote from human activity. | Schlabach *et al*. (2011) |
| Striped Bass (*Morone saxatilis*) (n=1)<br>Tilapia (*Oreochromis mossambicus*)] (n=1)<br>Cod (*Gadus morhua*) (n=1)<br>Atlantic Salmon (*Salmo salar*)] (n=1) | Muscle | Two Supermarket in Chung-Li city, Taiwan (the cod and salmon were imported, the other two species were locally caught). | 0.0003 µg/g lw (both isomers) | Anti-DP: range 0.034 – 0.300 µg/kg lw<br>Syn-DP: range 0.038 – 0.273 µg/kg lw<br>The highest concentrations occurred in the bass. | Analysis was by GC-MS. | Chen *et al*. (2014) |
| Fish (15 marine species) (n=20) | Muscle | Supermarkets in Osaka, Japan; June 2011 | 0.0002 | Detected in 18 out of 20 samples, up to 0.0142 µg/g ww | Analysis was by GC-MS. | Kakimoto *et al*. (2012) |
| Common Mullet<br>Oriental Goby<br>Steed Barbel<br>Temperate Sea Bass<br>Crucian Carp | Muscle | 22 rivers across South Korea from late July to early October 2008.<br>Urban-industrial: 15 sites<br>Rural-industrial: 3 sites | Not stated | Average total concentration:<br>Overall: 24.5 (range: 0.61 – 126) µg/kg lw<br>Urban-industrial region: 36.1±35.3 ng/g lw | Analysis was by GC- high resolution MS.<br>Both isomers were consistently detected in all fish samples regardless of sampling | Kang *et al*. (2010); Kang *et al*. (2009) [ABST]. |

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| (Latin names not provided) | | Rural: 4 sites<br>Fish were sampled twice at each site, and several individual fish carcasses were combined and homogenized to provide a pooled sample. | | Rural region: 1.4±1.0 µg/kg lw<br>Concentrations of syn- and anti-DP isomer ranged from 0.17 – 30 µg/kg lw and 0.44 – 97 µg/kg lw, respectively. The anti-DP isomer was dominant in all samples. The mean fanti value (0.67 ±0.060) was significantly lower than that of the technical product (0.75) (p = 0.032) suggesting that the syn- isomer may be more bioaccumulative. | sites and fish species. Mean concentrations at the urban sites were around 25 times greater than those at the rural sites. There is no manufacturing facility in South Korea. | |
| Mud Carp<br>(*Cirrhinus molitorella*) (n=10) | Muscle, liver & brain | Natural pond at an e-waste recycling site, South China; December 2009 | Anti-DP:<br>0.00052 (muscle) to 0.024 (brain) | Both isomers were detected in all samples. Median concentrations of total isomers were as follows:<br><br>Mud Carp<br>Muscle: 0.38 µg/kg ww<br>Liver: 9.55 µg/kg ww<br>Brain: 18.26 µg/kg ww<br>Northern Snakehead<br>Muscle: 0.76 µg/kg ww<br>Liver: 92.0 µg/kg ww<br>Brain: 11.8 µg/kg ww<br>Anti-DP-1Cl was detected in 100% of liver and 80% of muscle samples, with median concentrations of 0.01-5.63 µg/kg ww. Anti-DP-2Cl was detected in one muscle sample of Mud Carp, at a concentration of 0.01 µg/kg ww. Both isomers were detected in all five sediment samples collected at the same time (at concentrations from 6.32 to 25.0 (median: 12.0) µg/kg and from 0.42 to 0.83 (median: 0.64) µg/kg dw, respectively). | Analysis was by GC-MS.<br>Both species are associated with benthic environments. The median sediment concentration (total isomers) was above 3,000 µg/kg dw.<br>Higher levels of the anti-isomer were detected in the brain than liver or muscle for Mud Carp, whereas liver accumulated more of both isomers in Northern Snakehead. Lipid-normalized concentrations indicated preferential distribution to liver in both species, suggesting that hepatic proteins might be important in the accumulation of this substance. It appeared that there was enrichment of the syn- isomer in all tissues (except Northern Snakehead brain) compared to levels in sediment and the technical product.<br>The study shows that both isomers can cross the blood-brain barrier in fish. | Zhang *et al*. (2011a) |
| Northern Snakehead (*Channa argus*) (n=10) | Muscle, liver & brain | Natural pond at an e-waste recycling site, South China; December 2009 | Syn-DP: 0.0012 (muscle) to 0.055 (brain) | Both isomers were detected in all samples. Median concentrations of total isomers were as follows:<br><br>Mud Carp | Analysis was by GC-MS.<br>Both species are associated with benthic environments. The median sediment concentration (total | Zhang *et al*. (2011a) |

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| | | | | Muscle: 0.38 µg/kg ww<br>Liver: 9.55 µg/kg ww<br>Brain: 18.26 µg/kg ww<br>Northern Snakehead<br>Muscle: 0.76 µg/kg ww<br>Liver: 92.0 µg/kg ww<br>Brain: 11.8 µg/kg ww<br>Anti-DP-1Cl was detected in 100% of liver and 80% of muscle samples, with median concentrations of 0.01-5.63 µg/kg ww. Anti-DP-2Cl was detected in one muscle sample of Mud Carp, at a concentration of 0.01 µg/kg ww. Both isomers were detected in all five sediment samples collected at the same time (at concentrations from 6.32 to 25.0 (median: 12.0) µg/kg and from 0.42 to 0.83 (median: 0.64) µg/kg dw, respectively). | isomers) was above 3,000 µg/kg dw.<br>Higher levels of the anti-isomer were detected in the brain than liver or muscle for Mud Carp, whereas liver accumulated more of both isomers in Northern Snakehead. Lipid-normalized concentrations indicated preferential distribution to liver in both species, suggesting that hepatic proteins might be important in the accumulation of this substance. It appeared that there was enrichment of the syn- isomer in all tissues (except Northern Snakehead brain) compared to levels in sediment and the technical product.<br>The study shows that both isomers can cross the blood-brain barrier in fish. | |
| Mud Carp (*Cirrhinus molitorella*)<br>Northern Snakehead (*Ophicephalus argus*) | Blood serum | Electronics waste recycling site in south China, 2010. 3 pooled samples for each species each taken from 6 individuals. Each pooled sample was divided into 2 subsamples for analysis | 0.009-0.026 | Detected in all pooled samples<br>Mud Carp<br>Total isomers:<br>Mean: 0.3 µg/kg ww<br>Mean fanti = 0.44<br>Northern Snakehead<br>Total isomers:<br>Mean:4.6 µg/kg ww<br>Mean fanti = 0.56 | Analysis by GC-MS. The range of concentrations was given as 0.3-5.1 µg/kg ww or 47-727 µg/kg lw. The lipid weight concentrations are not given separately for each species.<br>The fanti in both species was significantly lower (*p*<0.001) than that in sediments from the area (fanti=0.755). | Zeng *et al.* (2014b) |
| Crucian Carp (*Carassius carassius*)<br>Common Carp (*Cyprinus carpio*)<br>Grass Carp (*Ctenopharyngodon idellus*)<br>Sharpbelly (*Hemiculter leucisculus*)<br>Pond Loach (*Misgurnus anguillicaudatus*) | Muscle | Liaohe River, Liaoning province, China; August 2010. 18 pooled samples (6 sites) | - | Detected in 17 out of 18 pooled samples<br>Total isomers:<br>Mean: 223 ng/kg lw<br>Median: 215 ng/kg lw<br>Range: not detected – 470 ng/kg lw | Analysis by GC-MS. | Ren *et al*. (2013) |
| Bleeker (*Pseudolaubuca sinensis*) (n = 12)<br>Loach (*Misgurnus anguillicaudatus*) (n = 7)<br>Crucian Carp (*Carassius auratus*) (n = 9)<br>Common Carp (*Cyprinus carpio*) (n = 8) | Muscle | Beijing–Hangzhou Grand Canal, Huai'an, Jiangsu province, China; May 2010. Five fish were pooled into composite | Anti-DP: 0.135<br>Syn-DP: 0.120 | Total isomers:<br>Mean: 764 (range of means for each species: 56.8 to 1 110) µg/kg ww | Analysis by GC- high resolution MS.<br>The site was downstream of the discharge point of the Chinese manufacturing facility. | Wang *et al*. (2013) |

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| Northern Snakehead (*Channa argus*) (n = 3) | | samples for each species (except Northern Snakehead). | | Mean: 67 500 µg/kg lw (range of means for each species: 2 760–96 800 µg/kg lw) | The highest mean concentration was 1.1 mg/kg ww in Common Carp, or 97 mg/kg lw in Bleeker. | |
| Mosquito Fish (*Gambusia affinis*) (n = 11)<br>Paradise Fish (*Macropodus opercularis*) (n = 9)<br>Chinese Hooksnout Carp (*Opsariichthys bidens*) (n = 18).<br>Chinese False Gudgeon (*Abbottina rivularis*) (n = 10)<br>Nichols' Minnow (*Nicholsicypris normalis*) (n = 6)<br>Chinese Bitterling (*Rhodeinae*) (n = 9) | Whole fish | E-waste recycling site & reference site (Dinghu Mountain) in the Pearl River Delta, Guangdong Province, southern China; March - July 2010. Fish were pooled into composites for each species at each site. | Anti-DP: 0.59 (lw)<br>Syn-DP: 0.14 (lw) | E-waste recycling site (29 fish, 9 composites)<br>Total isomers: medians per species: 79-410 µg/kg lw (overall range 60-420 µg/kg lw)<br>Reference site (34 fish, 12 composites)<br>Total isomers: medians per species: 1.7-8.4 µg/kg lw (overall range 0.96-8.8 µg/kg lw)<br>Anti-DP-1Cl was detected in all samples collected from the e-waste recycling site (range: 2.4-14 µg/kg lw), but not at the reference site (LoD 0.09 µg/kg lw). Anti-DP-2Cl was not detected in any sample (LoD 0.01 µg/kg lw). | Analysis by GC-MS.<br>The e-waste site is in a heavily industrialized area. The reference site is in a relatively non-contaminated agricultural area. | Mo *et al*. (2013) |
| Greenland Shark (*Somniosus microcephalus*) | Liver | Female sharks by-caught in a commercial fishery in the waters around Iceland, northeast Atlantic, between April 2001 and October 2003 (n=15). | Not stated | Not stated. | The paper provides quantitative data on three target compounds that were "routinely" detected in the liver samples, but does not comment on the concentrations or detection frequencies of the other substances that were included in the analysis (including Dechlorane Plus).<br>In summarising this study, Vorkamp & Rigét (2014) stated that Dechlorane Plus was "not detected", but this might be misleading. | Strid *et al*. (2013) |
| Brown trout (*Salmo trutta*) | Fillet | One location in Lake Mjøsa, Norway, August 2016. | Anti-DP: 0.14<br>Syn-DP: 0.03 | Not detected in 10 fillet samples | Number of fish not specified | Schlabach *et al*. (2017) |

**Table 8. Detection of Dechlorane monoadduct (DPMA) in environmental samples (IN PREPARATION)**

| Matrix | Country/Region | Year | n | Concentration | | | Comment | Reference |
|---|---|---|---|---|---|---|---|---|
| | | | | 1,5-DPMA | 1,3-DPMA | ΣDP | | |
| | | | | | | | | Sverko et al., 2010 |
| | | | | | | | | Tomy et al., 2007 |
| Plankton | Canada, Lake Ontario | 2000-2003 | 1 | nd | 199 ng/g lw | 2.05 ng/g lw | | Tomy et al., 2013 |
| Diphoreia | Canada, Lake Ontario | 2000-2003 | 1 | nd | 56.1 ng/g lw | 5.87 ng/g lw | | Tomy et al., 2013 |
| Alewife | Canada, Lake Ontario | 2000-2003 | 2 | 7.9, 15.1 ng/g lw | 3.40, nd ng/g lw | 0.102, 0.082 ng/g lw | | Tomy et al., 2013 |
| Smelt | Canada, Lake Ontario | 2000-2003 | 2 | nd | 5.9, 7.8 | 0.01, 0.026 ng/g lw | | Tomy et al., 2013 |
| Sculpin | Canada, Lake Ontario | 2000-2003 | 3 | 25.8, 22.2, 21.7 ng/g lw | 16.4, 24.3, 101 ng/g lw | 1.36, 2.91, 0.502 ng/g lw | | Tomy et al., 2013 |
| Trout | Canada, Lake Ontario | 2000-2003 | 4 | nd | 0.5, 0.12, 0.22, 0.41 ng/g lw | 0.107, 0.062, 0.076, 0.576 ng/g lw | | Tomy et al., 2013 |
| | | | | | | | | Sühring et al., 2014 |
| | | | | | | | | Wang et al., 2015 |
| | | | | | | | | Wolsche et al., 2015 |
| | | | | | | | | Rajabova et al., 2016 |
| Peregrine falcon egg | Canada | | | | | | | Guerra et al., 2011 |
| Peregrine falcon egg | Spain | | | | | | | Guerra et al., 2011 |

## Table 9. *Indoor air* and dust

| Matrix | Country/ Region | Year | N | Study site<br>Type of location | Mean (range) in ng/g,<br>*air concentrations in pg/m3*<br>detection frequency % | | | Comment | References |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Syn*-DP | *Anti*-DP | Mean ΣDP | | |
| *Indoor air* | *Norway* | *2012* | *47* | *Residential living rooms* | *0.18 (<MLD-7.39) 2%* | *0.28 (<MLD-7.61) 4%* | *0.457* | | *Cequier et. al., 2014* |
| *Indoor air* | *Norway* | *2012* | *6* | *School classrooms* | *<MLD 0%* | *<MLD 0%* | *-* | | *Cequier et. al., 2014* |
| *Indoor air* | *Norway* | *2013-14* | *60* | *Residential living rooms* | *<1.2 (<1.2-150) 25%* | *<1.3 (<1.3-47) 15%* | | | *Tay et al., 2017* |
| *Indoor air* | *United Kingdom* | *2013-1015* | *20* | *Office* | *1.3 (<2.0-7.7)<br>5%* | *1.8 (<1.2-24)<br>5%* | | | *Tao et al., 2016* |
| *Indoor air* | *United Kingdom* | *2013-1015* | *15* | *Residential houses* | *<2.0 (<2.0-4.6,<br>7%* | *2.2 (<1.2-20)<br>20%* | | | *Tao et al., 2016* |
| *Indoor air* | *U.S* | | | *Residential houses* | *0.37 (nd-4.0)* | *4.1(nd-23)* | | | *Venier et al., 2016* |
| *Indoor air* | *Canada* | | | *Residential houses* | *23 (nd-76)* | *25 (nd-243)* | | | *Venier et al., 2016* |
| *Indoor air* | *Czech Republic* | | | *Residential houses* | *-* | *65 (nd-65)* | | | *Venier et al., 2016* |
| Dust | Norway | 2012 | 48 | Residential living rooms | 9.07 (max 311) 92% | 18.9 (max 590) 92% | 27.97 | Concentration of DP was negatively correlated with number of "Picture tube TVs", p= 0.018 and 0.04, for syn and anti-DP, respectively, and positive correlated with age of the woman (p=0.000) | Cequier et. al., 2014 |
| Dust | Norway | 2012 | 6 | School classrooms | 1.31 (max 3.13) 83% | 3.68 (max 9.25) 100% | 4.99 | | Cequier et. al., 2014 |
| Dust | Norway | 2013-14 | 61 | Settled dust, residential homes | 2.3 (<0.51-62) 48% | 8.3 (<0.34-120) 72% | | | Tay et al., 2017 |
| Dust | United Kingdom | 2013-1015 | 42 | Office | 60 (<0.26-640),<br>98% | 210 (<0.15-2100)<br>98% | 270 | | Tao et al., 2016 |
| Dust | United Kingdom | 2013-1015 | 30 | Residential houses | 3.6 (<0.26-28)<br>63% | 21 (<0.15-170)<br>84% | 24.6 | | Tao et al., 2016 |
| Dust | Egypt, Cairo | 2013 | 17 | Residential houses | 0.63 (<0.02-2.28)<br>71% | 0.39 (<0.01-1.70)<br>47% | | | Hasan and Shoeib, 2015 |
| Dust | Egypt, Cairo | 2013 | 5 | Workplaces | 1.42 (0.02-2.88) 100% | 0.37 (0.01-0.95) 80% | | | Hassan and Shoeib, 2015 |
| Dust | Egypt, Cairo | 2013 | 9 | Cars | 2.10 (<0.02-4.94) 100% | 1.65 (0.01-0.95) 100% | | | Hassan and Shoeib, 2015 |
| Dust | Canada, Vancouver | 2007-2008 | 116 | Residential houses | 7.5 (<0.70-170) 99% | 11 (<0.70-170)<br>99% | | Whole vacuum cleaner bag | Shoeib et al., 2012 |
| Dust | United States of America, Massachusetts | 2002-2003 | 38 | Residential houses | 3.16 (max 43.1) 89% | 9.60 (max 68.4),<br>100% | | Whole vacuum cleaner bag | Johnson et al., 2013 |

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|---|---|---|---|---|---|---|---|---|---|
| Dust | Australia (A), United Kingdom (UK), Canada (CA), Sweden (S), China (CH) | A: 2014, UK: 2008-2009, CA: 2014, S: 2014, CH: 2012 | A=4, UK=4, CA=6, S= 5, CH=5 | A: Office, UK: house bedroom, CA, S, CH: office | 0.04 (0.018-0.19) 100% | 0.04 (0.013-0.15) 100% | 0.079, (0.032-0.31) | | Wong et al., 2017 |
| Dust | United States of America | 2015 | 12 | Student campus, common area. Furniture flammability standard TB133 | | | 340, (max 2800), 100% | Campus purchased institutional furniture to meet California's TB133 (which requires furniture to withstand a much larger and longer test flame than TB117) | Dodson et al., 2017 |
| Dust | United States of America | 2015 | 42 | Student campus, dormitory. Furniture flammability standard TB133 | | | 140, (max 1900), 100% | Campus purchased institutional furniture to meet California's TB133 (which requires furniture to withstand a much larger and longer test flame than TB117) | Dodson et al., 2017 |
| Dust | United States of America | 2015 | 15 | Student campus common area. Furniture flammability standard TB117 | | | 15, (max 38), 100% | Campus purchased institutional furniture to meet California's TB117 (The other standard, TB133 requires furniture to withstand a much larger and longer test flame than TB117) | Dodson et al., 2017 |

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|---|---|---|---|---|---|---|---|---|---|
| Dust | United States of America | 2015 | 26 | Student campus, dormitory. Furniture flammability standard TB117 | | | 19, (max 130), 100% | Campus purchased institutional furniture to meet California's TB117 (The other standard, TB133 requires furniture to withstand a much larger and longer test flame than TB117) | Dodson et al., 2017 |
| Dust | United States of America | 2010 | 19 air-planes, 40 samples | Airplane | 110 (40-9500) 100% | 330 (92-4200) 100% | | Carpet dust. Airplanes represented a wide range of manufacturing dates (1986 – 2008) from five manufacturers (Boeing, Airbus, Canadair Regional, McDonnell Douglas and Embraer). | Allen et al., 2013 |
| Dust | United States of America | 2010 | 19 airplanes, 40 samples | Airplane | 160 (34-2200) 100% | 300 (31-9600) 100% | | Air return grills. Airplanes represented a wide range of manufacturing dates (1986 – 2008) from five manufacturers (Boeing, Airbus, Canadair Regional, McDonnell Douglas and Embraer). | Allen et al., 2013 |
| Dust | China, Beijing | 2012 | 3 | Hotels | - | - | 124,000 | Highest level of DP in small particles, 7-20 µm | Cao et al., 2014 |
| Dust | China, Beijing | 2012 | 2 | Kindergarten | - | - | 231 | Highest level of DP in small particles, 7-20 µm | Cao et al., 2014 |
| Dust | China, Beijing | 2012 | 2 | Kindergarten | - | - | 1,350 | 12± 10 µm, dust particle fraction | Cao et al., 2014 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Dust | China, Beijing | 2012 | 2 | Kindergarten | - | - | 1,530 | 7± 7 µm, dust particle fraction | Cao et al., 2014 |
| Dust | China, Beijing | 2012 | 40 | Dormitories | - | - | 14,200 | Carpeted, Highest level of DP in small particles, 7-20 µm | Cao et al., 2014 |
| Dust, | China, Dongguan | 2013 | 102 | Indoor | - | - | 68.5 (nd-622) | Highest level of DP in small particles, 7-20 µm | Chen et al., 2014 |
| Dust | China, Dongguan | 2013 | 20 | outdoor | - | - | 22.9, (1.44-93.1) | | Chen et al., 2014 |
| Dust | China, Guangzhou | | 51 | House dust | 5.3 (<LOD-216) 78% | 19.4 (<LOD-834) 98% | 24.5, (nd-1050) | Median. DBDPE dominated | Tang et al., 2019 |
| Dust | China, Guangzhou | | 31 | Children's hand wipe | 0.02 (nd-0.2) 68% | 0.1 (nd-1.4) 97% | 0.1, (nd-15) | Median. DBDPE, DE209 and BEH-TEBP dominated | Tang et al., 2019 |
| Dust | China, Guangzhou | | 51 | Adults' hand wipe | 0.04 (nd-1.5) 76% | 0.14 (nd-5.3) 94% | 0.2, (nd-5.6) | Median. DBDPE, BDE209 and BEH-TEBP dominated | Tang et al., 2019 |

DBDPE= decabromodiphenylethane
BDE209= decabromodiphenylether
BEH-TEBP= bis(2-ethylhexyl)- 3,4,5,6-tetrabromo-phthalate

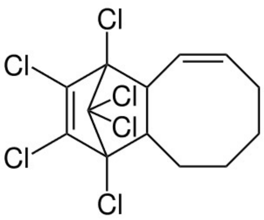
**Table 10. Median concentration (ng/g lipid) of Dechlorane Plus and its isomers and de-chlorinated DP in human samples**

| **Region** | **Matrix** | **Year** | ***n*** | **Detection frequency %, *syn; anti*-DP** | ***Syn*-DP** | ***Anti*-DP** | **ΣDP median** | **Σ DP range** | ***Anti*-$Cl_{11}$-DP** | ***f*-*anti*** | **Reference** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Norway | Serum | 2012 | 48 | 78; 89 | 0.45 | 0.85 | 1.3 | | - | 0.67 | Cequier et al., 2015 |
| Norway | Serum | 2013 | 61 | 3; 3 | <0.80 | <2.1 | | | | | Tay et al., 2019 |
| Germany, Red Cross donors | Serum | 2013-14 | 42 | 93; 79 | 0.77 | 1.23 | | | - | 0.57 | Fromme et al., 2015 |
| France, people living in area of a municipal solid waste incinerator | Serum | 2003-05 | 48 | 75; 94 | 0.22 | 0.89 | 1.20 | | - | 0.75 | Brasseur et al., 2014 |
| Canada, maternal serum | Serum | 2007-09 | 102 | 77; 87 | 0.49 | 1.9 | 2.37 | | | 0.81 | Zhou et al., 2014 |
| Korea | Serum | 2013 | 61 | | 0.21 | 0.52 | 0.75 | | | 0.74 | Kim et al., 2016 |
| China, residents of Shandong Province | Serum | 2014 | 490 in 20 pooled samples | | - | - | 2.1 (mean) | | | 0.62-0.82 | Ma et al., 2017 |
| China, residents of Shandong Province | Serum | 2015 | 452 in 20 pooled samples | | - | - | 3.1 (mean) | | | 0.62-0.82 | Ma et al., 2017 |

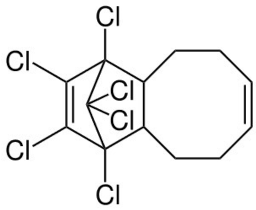
| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| China, surplus serum from routine pathology testing, residents of Laizhou Bay, within 10 km from previous production site male | Serum | 2011 | 146 in 5 pooled | | 3.1(mean) | 1.1 (mean) | 4.3 (mean) | | | | He et al., 2013; Wang et al., 2014; |
| China, surplus serum from routine pathology testing residents of Laizhou Bay, within 10 km from previous production site female | Serum | 2011 | 141 in 5 pooled | | 2.0(mean) | 0.95(mean) | 2.9 (mean) | | | | Wang et al., 2014; He et al., 2013 |
| | | | | | | | | | | | |
| China, e-waste dismantling region | Serum | 2005 | 20 | | 17.10 | 21.20 | 42.6 | | | 0.53 | Ren et al., 2009; 2011 |
| China, fishing industry region | Serum | 2005 | 20 | | 5.10 | 8.60 | 13.7 | | | 0.64 | Ren et al., 2009; 2011 |
| China | Serum | 2011 | 10 | | 2.50 | 1.00 | 3.6 | | | 0.35 | He et al., 2013 |
| China, > 20 yrs residential time in e-waste recycling region | Serum | 2010-11 | 33 | | 2.75 | 5.95 | 8.64 | | | 0.70 | Ben et al., 2013 |
| China, < 3 yrs residential time in e-waste recycling region | Serum | 2010-11 | 16 | | 0.95 | 2.71 | 4.09 | | | 0.75 | Ben et al., 2013 |
| China, > 20 yrs residential time in e-waste recycling region | Maternal serum | 2010-11 | 48 | | 2.40 | 6.16 | 8.43 | 1.28-900 | 0.371 | 0.72 | Ben et al., 2014 |
| China, < 3 yrs residential time in e-waste recycling region | Maternal serum | 2010-11 | 20 | | 0.82 | 2.83 | 3.55 | 1.69-11.6 | 0.155 | 0.75 | Ben et al., 2014 |
| China, occupational exposure DP plant | Blood | 2011 | 23 | | 386 | 471 | 857 | | | 0.54 | Zhang et al., 2013 |
| China, workers without direct DP exposure | Blood | 2011 | 12 | | 143 | 207 | 350 | | | 0.60 | Zhang et al., 2013 |
| China, residents near DP manufacturing plant | Blood | 2011 | 12 | | 106 | 207 | 243 | | | 0.61 | Zhang et al., 2013 |
| China, > 20 yrs residential time in e-waste recycling region | Cord blood | 2010-11 | 48 | | 0.959 | 1.89 | 2.82 | 0.680-89.7 | | 0.67 | Ben et al., 2014 |
| China, < 3 yrs residential time in e-waste recycling region | Cord blood | 2010-11 | 20 | | 0.660 | 1.40 | 1.82 | 0.450-27.2 | | 0.67 | Ben et al., 2014 |
| China, > 20 yrs residential time in e-waste recycling region | Placenta tissue | 2010-11 | 48 | | 0.728 | 2.75 | 3.21 | 0.92-197 | 0.0767 | 0.74 | Ben et al., 2014 |
| China, < 3 yrs residential time in e-waste recycling region | Placenta tissue | 2010-11 | 20 | | 0.32 | 0.90 | 1.09 | 0.459-2.86 | | 0.75 | Ben et al., 2014 |
| Canada | Milk | 2004, 2009 | 87 | 74; 85 | 0.27 | 0.71 | 0.98 | | | 0.67 | Siddique et al., 2012 |
| Canada | Milk | 2007-09 | 105 | 40; 50 | nd | 0.02 | 0.02 | | | 0.80 | Zhou et al., 2014 |
| China, > 20 yrs residential time in e-waste recycling region | Milk | 2010-11 | 33 | | 1.33 | 3.32 | 4.46 | | | 0.71 | Ben et al., 2013 |
| China, < 3 yrs residential time in e-waste recycling region | Milk | 2010-11 | 16 | | 0.50 | 1.58 | 2.19 | | | 0.76 | Ben et al., 2013 |

**Figure 1. Two different isomers of Dechlorane Plus monoadduct (DPMA) has been detected in the environment**

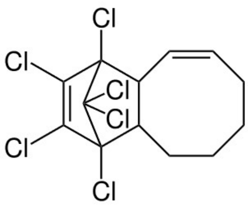
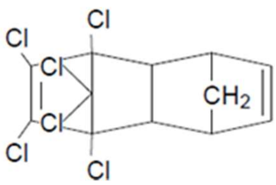
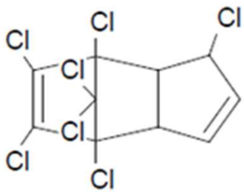
**1,5-DPMA**



**1,3-DPMA**



### Table 11x. Dechlorane Plus monoadduct and possible grouping approach

| Properties | DPMA | Aldrin | Heptachlor |
|---|---|---|---|
| Prediction<br><br>OECD QSAR Toolbox v2.1 |  |  |  |
| Molecular diameter Å | 8.7 | 8.7 | 8.6 |
| Van der Waals's volume, Å | 231 | 210 | 202 |
| MW | 380.96 | 364.92 | 373.32 |
| Water solubility, 25C | 0.003 mg/L | 0.017 mg/L | 0.18 mg/L |
| Log Kow | 7.2 (predicted) | 6.5 (measured) | 5.5-6.1 (measured) |

Information from ECHA, 2017c.

Both Aldrin and heptachlor are listed in Stockholm Convention.

"WHO (1989) reports that aldrin is rapidly converted to dieldrin by epoxidation of the double bond in the environment, and that a large number of microorganisms are capable of promoting epoxidation. Aldrin and dieldrin are highly toxic substances47, and dieldrin is much more resistant to biodegradation (WHO, 1989). Their historical use as neurotoxic insecticides means that they target the central nervous system, but a variety of other effects have been observed in mammals and birds, including on the immune system and liver (WHO, 1989). The mode of action could involve the alkyl bridge (e.g. via hydroxylation), so this does not automatically mean that DPMA would cause effects of the same type or at similar concentrations.

Heptachlor is also highly toxic. EFSA (2007) highlights that the two main transformation products of heptachlor – heptachlor epoxide and photoheptachlor – are persistent, lipophilic and toxic" ECHA, 2017c.

**References [TO BE COMPLETED]**


Allen JG, Stapleton HM, Vallarino J, McNeely E, McClean MD, Harrad SJ, Rauert CB, Spengler JD (2013). Exposure to flame retardant chemicals on commercial airplanes. Environ Health 12:17.

Barón E, Eljarrat E, Barceló D (2012). Analytical method for the determination of halogenated norbornene flame retardants in environmental and biota matrices by gas chromatography coupled to tandem mass spectrometry. J Chromatogr A. 1248:154-60.

Barón E, Santín G, Eljarrat E, Barceló D (2014b?). Occurrence of classic and emerging halogenated flame retardants in sediment and sludge from Ebro and Llobregat river basins (Spain). J Hazard Mater. 30; 265:288-95.

Ben Y-J, Li X-H, Yang Y-L, Li L, Zheng M-Y, Wang W-Y, Xu X-B (2014). Placental Transfer of Dechlorane Plus in Mother−Infant Pairs in an E-Waste Recycling Area (Wenling, China.) Environ. Sci. Technol. 48, 5187−5193.

Ben Y-J, Li X-H, Yang Y-L, Li L, Di J-P, Wang W-Y, Zhou R-F, Xiao K, Zheng M-Y, Tian Y, Xu X-B (2013). Dechlorane Plus and its dechlorinated analogs from an e-waste recycling center in maternal serum and breast milk of women in Wenling, China. Environmental Pollution. 173, 176-181

Cao Z, Xu F, Covaci A, Wu M, Wang H, Yu G, Wang B, Deng S, Huang J, Wang X (2014). Distribution patterns of brominated, chlorinated, and phosphorus flame retardants with particle size in indoor and outdoor dust and implications for human exposure. Environmental Science and Technology, 48, 8839–884

Cequier E, Marcé RM, BecherG, Thomsen C (2015). Comparing human exposure to emerging and legacy flame retardants from the indoor environment and diet with concentrations measured in serum. Environment International. 85, 292–298.

Cequier E, Ionas AC, Covaci A, Marce RM, Becher G, Thomsen C (2014). Occurrence of a broad range of legacy and emerging flame retardants in indoor environments in Norway. Environ. Sci. Technol. 48, 6827−6835.

Davis EF, Klosterhaus SL, Stapleton HM (2012). Measurement of flame retardants and triclosan in municipal sewage sludge and biosolids. Environ Int. 40:1-7.

de la Torre A, Sverko E, Alaee M, Martínez MÁ (2011). Concentrations and sources of Dechlorane Plus in sewage sludge. Chemosphere. 82(5):692-7.

Dodson RE, Rodgers KM, Carey G, Laurent JGC, Covaci A, Poma G, Malarvannan G, Spengler JD, Rudel RA, Allen JG (2017). Flame retardant chemicals in college dormitories: Flammability standards influence dust concentrations. Environ. Sci. Technol. 51, 4860−4869

ECHA (2017b). Dechlorane Plus; Proposal for identification of a substance of very high concern on the basis of the criteria set out in REACH Article 57. Annex XV report. Available at: https://echa.europa.eu/documents/10162/6ba01c40-009a-8388-1556-d8caa50d2b4f

ECHA (2017c). Annex XV Appendix - Identification of Dechlorane Plus as SVHC. Detailed summaries of the data cited in the main report. Available at: https://echa.europa.eu/documents/10162/86c6520a-cdc8-86bf-cc86-57beef04bc6f

EFSA (2007). Opinion of the Scientific Panel on Contaminants in the Food Chain on a Request from the European Commission Related to Heptachlor as an Undesirable Substance in Animal Feed. Question N° EFSA-Q-2005-184. The EFSA Journal, 478, 1-48.

Fromme H, Cequier E, Kim JT, Hanssen L, Hilger B, Thomsen C, Chang YS, Völkel W (2015). Persistent and emerging pollutants in the blood of German adults: Occurrence of dechloranes, polychlorinated naphthalenes, and siloxanes. Environ Int. 85:292-8. doi: 10.1016/j.envint.2015.09.002.

Gravel S, Lavoué J, Bakhiyi B, Diamond ML, Jantunen LM, Lavoie J, Roberge B, Verner MA, Zayed J, Labrèche F (2019). Halogenated flame retardants and organophosphate esters in the air of electronic waste recycling facilities: Evidence of high concentrations and multiple exposures. Environ Int. 128:244-253.

Hassan and Shoeib, (2015). Levels of polybrominated diphenyl ethers and novel flame retardants in microenvironment dust from Egypt: an assessment of human exposure. Sci Total Environ.;505:47-55.

He S, Li M, Jin J, Wang Y, Bu Y, Xu M, Yang X, Liu A (2013). Concentrations and trends of halogenated flame retardants in the pooled serum of residents of Laizhou Bay, China. Environ Toxicol Chem.32(6):1242-7.

Johnson PI, Stapleton HM, Mukherjee B, Hauser R, Meeker JD (2013). Associations between brominated flame retardants in house dust and hormone levels in men. Sci Total Environ 445-446:177-184

Kim J, Son M-h, Shin E-s, Choi S-D, Chang Y-S (2016). Occurrence of Dechlorane compounds and polybrominated diphenyl ethers (PBDEs) in the Korean general population. Environmental Pollution. 212, 330-336.

Kim JT, Son MH, Kang JH, Kim JH, Jung JW, Chang YS (2015). Occurrence of Legacy and New Persistent Organic Pollutants in Avian Tissues from King George Island, Antarctica. Environ Sci Technol. 49(22):13628-38.

Kurt-Karakus PB, Muir DC, de Jourdan B, Teixeira C, Martindale JE, Embers H, Wang X, Keir M, Backus S (2019). Bioaccumulation of selected halogenated organic flame retardants in Lake Ontario. Environmental Toxicology and Chemistry—Volume 38, Number 6—pp. 1198–1210

Ma Y, Li P, Jin J, Wang Y, Wang Q (2017). Current halogenated flame retardant concentrations in serum from residents of Shandong Province, China, and temporal changes in the concentrations. Environ Res. 155:116-122.

Na G, Yao Y, Gao H, Li R, Ge L, Titaley IA, Santiago-Delgado L, Massey Simonich SL (2017). Trophic magnification of Dechlorane Plus in the marine food webs of Fildes Peninsula in Antarctica. Mar Pollut Bull. 117(1-2):456-461.

Norwegian Environment Agency (2019a). Environmental Contaminants in an Urban fjord. Report L. Nr. 7410-2019/M-1441.

Norwegian Environment Agency (2018b). Environmental Contaminants in an Urban fjord. Report M-1131.

Qiu XH, Marvin CH and Hites RA (2007). Dechlorane plus and other flame retardants in a sediment core from Lake Ontario. Environ. Sci. Technol. 41 (17), 6014–6019.

Ren G-F, Luo X-F, Ma S-T, Sun Y-F, Yu Z-Q, Sheng G-Y, Fu J-M (2011). Quantification of Dechlorane Plus in Human Serum by Gas Chromatography Coupled with Negative Chemical Ionization Mass Spectrometry. Chin J Anal Chem. 39(2), 235–238.

Ren GF, Yu ZQ, Ma ST, Li HR, Peng PG, Sheng GY, Fu JM (2009). Determination of Dechlorane Plus in serum from electronics dismantling workers in South China. Environ Sci Technol 43 (24), 9453–9457.

Siddique S, Xian QM, Abdelouahab N, Takser L, Phillips SP, Feng YL, Wang B, Zhu JP (2012). Levels of dechlorane plus and polybrominated diphenylethers in human milk in two Canadian cities. Environ. Int. 39 (1), 50–55.

She YZ, Wu JP, Zhang Y, Peng Y, Mo L, Luo XJ, Mai BX (2013). Bioaccumulation of polybrominated diphenyl ethers and several alternative halogenated flame retardants in a small herbivorous food chain. Environ Pollut. 174:164-70.

Shen L, Reiner EJ, Helm PA, Marvin CH, Hill B, Zhang X, Macpherson KA, Kolic TM, Tomy GT, Brindle ID (2011a). Historic trends of dechloranes 602, 603, 604, dechlorane plus and other norbornene derivatives and their bioaccumulation potential in Lake Ontario. Environ Sci Technol. 45(8):3333-40.

Shen L, Reiner EJ, MacPherson KA, Kolic TM, Helm PA, Richman LA, Marvin CH, Burniston DA, Hill B, Brindle ID, McCrindle R, Chittim BG (2011b). Dechloranes 602, 603, 604, Dechlorane Plus, and Chlordene Plus, a newly detected analogue, in tributary sediments of the Laurentian Great Lakes. Environ Sci Technol. 45(2):693-9.

Shoeib M, Harner T, Webster GM, Sverko E, Cheng Y (2012). Legacy and current-use flame retardants in house dust from Vancouver, Canada. Environ. Pollut. 169, 175-182.

Sun YX, Hu YX, Zhang ZW, Xu XR, Li HX, Zuo LZ, Zhong Y, Sun H, Mai BX (2017). Halogenated organic pollutants in marine biota from the Xuande Atoll, South China Sea: Levels, biomagnification and dietary exposure. Mar Pollut Bull. 118(1-2):413-419.

Sun YX, Zhang ZW, Xu XR, Hu YX, Luo XJ, Cai MG, Mai BX (2015). Bioaccumulation and biomagnification of halogenated organic pollutants in mangrove biota from the Pearl River Estuary, South China. Mar Pollut Bull. 15;99(1-2):150-6.

Sverko E, Tomy GT, Marvin CH, Zaruk D, Reiner E, Helm PA, Hill B, McCarry BE (2008). Dechlorane plus levels in sediment of the lower Great Lakes. Environ Sci Technol. 42(2):361-6.

Tang S, Tan H, Liu X, Chen D (2019). Legacy and alternative flame retardants in house dust and hand wipes from South China. Science of the Total Environment. 656, 1–8.

Tang B, Luo XJ, Huang CC, Sun RX, Wang T, Zeng YH, Mai BX (2018). Stereoselective bioaccumulation of syn- and anti-Dechlorane plus isomers in different tissues of common carp (Cyprinus carpio). Sci Total Environ. 616-617:1339-1346.

Tao F, Abdallah MA-E, Harrad S (2016). Emerging and Legacy Flame Retardants in UK Indoor Air and Dust: Evidence for Replacement of PBDEs by Emerging Flame Retardants? Environ. Sci. Technol. 50, 13052−13061

Tay JH, Sellström U, Papadopoulou E, Padilla-Sánchez JA, Haug LS,. de Wit CA (2019). Serum concentrations of legacy and emerging halogenated flame retardants in a Norwegian cohort: Relationship to external exposure. *Environmental Research. 178, 108731*

Tomy GT, Thomas CR, Zidane TM, Murison KE, Pleskach K, Hare J, Arsenault G, Marvin CH, Sverko E (2008). Examination of isomer specific bioaccumulation parameters and potential in vivo hepatic metabolites of syn- and anti-Dechlorane Plus isomers in juvenile rainbow trout (Oncorhynchus mykiss). Environ Sci Technol. 42(15):5562-7.

Tomy GT, Pleskach K, Ismail N, Whittle DM, Helm PA, Sverko E, Zaruk D, Marvin CH (2007). Isomers of dechlorane plus in Lake Winnipeg and Lake Ontario food webs. Environ Sci Technol. 1;41(7):2249-54.

Venier M, Audy O, Vojta Š, Bečanová J, Romanak K, Melymuk L, Krátká M, Kukučka P, Okeme J, Saini A, Diamond ML, Klánová J (2016). Brominated flame retardants in the indoor environment — Comparative study of indoor contamination from three countries. *Environ. Int. 94*, 150-160.

Wang D, Jia H, Hong WJ, Xue X, Sun Y, Li YF, Guo W (2019). Uptake, depuration, bioaccumulation, and selective enrichment of dechlorane plus in common carp (Cyprinus carpio). Environ Sci Pollut Res Int. doi:10.1007/s11356-019-07239-8. [Epub ahead of print] PubMed PMID: 31865567.

Wang DG, Guo MX, Pei W, Byer JD, Wang Z (2015). Trophic magnification of chlorinated flame retardants and their dechlorinated analogues in a fresh water food web. Chemosphere. 118:293-300.

Wang Y, Xu M, Jin J, He S, Li M, Sun Y (2014). Concentrations and relationships between classes of persistent halogenated organic compounds in pooled human serum samples and air from Laizhou Bay, China. Science of the Total Environment. 482–483, 276–282.

Wang DG, Yang M, Qi H, Sverko E, Ma WL, Li YF, Alaee M, Reiner EJ and Shen L (2010a). An Asia-specific source of Dechlorane Plus: concentration, isomer profiles, and other related compounds. Environ. Sci. Technol. 44 (17): 6608–6613.

Wang X-P, Gong P, Yao T-D, Jones KC (2010b). Passive air sampling of organochlorine pesticides, polychlorinated biphenyls, and polybrominated diphenyl ethers across the Tibetan Plateau. Environmental Science and Technology. 44: 2988–2993.

WHO (1989). International Programme On Chemical Safety Environmental Health Criteria 91 aldrin and dieldrin. Geneva.

Wong F, Suzuki G, Michinaka C, Yuan B, Takigami H, de Wit CA (2017). Dioxin-like activities, halogenated flame retardants, organophosphate esters and chlorinated paraffins in dust from Australia, the United Kingdom, Canada, Sweden and China. Chemosphere 168: 1248-1256

Wu JP, Chen XY, Si-Kang W, Sun Y, Feng WL, Tao L, Luo XJ, Mai BX (2018). Dechlorane Plus flame retardant in a contaminated frog species: Biomagnification and isomer-specific transfer from females to their eggs. Chemosphere. 211:218-225.

Wu Q, Li H, Kuo DTF, Chen S, Mai B, Li H, Liu Z, Deng M, Zhang H, Hu X, Geng X, Chen Y (2017). Occurrence of PBDEs and alternative halogenated flame retardants in sewage sludge from the industrial city of Guangzhou, China. Environ Pollut. 220(Pt A):63-71.

Wu JP, Zhang Y, Luo XJ, Wang J, Chen SJ, Guan YT, Mai BX (2010). Isomer-specific bioaccumulation and trophic transfer of Dechlorane Plus in the freshwater food web from a highly contaminated site, South China. Environ Sci Technol. 15;44(2):606-11

Xiang N, Chen L, Meng XZ, Li YL, Liu Z, Wu B, Dai L, Dai X (2014). Polybrominated diphenyl ethers (PBDEs) and dechlorane plus (DP) in a conventional wastewater treatment plant (WWTP) in Shanghai: seasonal variations and potential sources. Sci Total Environ. 15; 487:342-9.

Xiang N, Zhao X, Meng XZ, Chen L (2013). Polybrominated diphenyl ethers (PBDEs) in a conventional wastewater treatment plant (WWTP) from Shanghai, the Yangtze River Delta: implication for input source and mass loading. Sci Total Environ. 461-462:391-6.

Xu P, Tao B, Zhou Z, Fan S, Zhang T, Liu A, Dong S, Yuan J, Li H, Chen J, Huang Y (2017). Occurrence, composition, source, and regional distribution of halogenated flame retardants and polybrominated dibenzo-p-dioxin/dibenzofuran in the soils of Guiyu, China. Environ Pollut. 228:61-71.

Yang R, Wei H, Guo J, McLeod C, Li A, Sturchio NC (2011). Historically and currently used Dechloranes in the sediments of the Great Lakes. Environ Sci Technol. 45(12):5156-63. Erratum in: Environ Sci Technol. 2011 45(21):9467.

Yu L, Luo X, Zheng X, Zeng Y, Chen D, Wu J, Mai B (2013). Occurrence and biomagnification of organohalogen pollutants in two terrestrial predatory food chains. Chemosphere. 93(3):506-11.

Yu Z, Lu S, Gao S, Wang J, Li H, Zeng X, Sheng G, Fu J (2010). Levels and isomer profiles of Dechlorane Plus in the surface soils from e-waste recycling areas and industrial areas in South China. Environ Pollut. 158(9):2920-5.

Zhang Q, Zhu C, Zhang H, Wang P, Li Y, Ren D, Jiang G (2015). Concentrations and distributions of Dechlorane Plus in environmental samples around a Dechlorane Plus manufacturing plant in East China. Sci. Bull. 60(8):792–797.

Zhang Y, Wu JP, Luo XJ, Wang J, Chen SJ, Mai BX (2011). Tissue distribution of Dechlorane Plus and its dechlorinated analogs in contaminated fish: high affinity to the brain for anti-DP. Environ Pollut. 159(12):3647-52.

Zhou S, Fu J, He H, Fu J, Tang Q, Dong M, Pan Y, Li A, Liu W, Zhang L (2017). Spatial distribution and implications to sources of halogenated flame retardants in riverine sediments of Taizhou, an intense e-waste recycling area in eastern China. Chemosphere. 184:1202-1208.

Zhou SN, Siddique S, Lavoie L, Takser L, Abdelouahab N, Zhu J (2014). Hexachloronorbornene-based flame retardants in humans: Levels in maternal serum and milk. Environ Int 66:11-17