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Leaching of problematic substances during storage of WEEE

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Content

List of abbreviations

BFR	Brominated flame retardant(s)
BBP	Benzylbutylphthalate
BB-153	Brominated biphenyl 153
BEH-TBP	bis(2-ethylhexyl)tetrabromophthalate (same as TBPH)
BTBPE	1,2-Bis(2,4,6-tribromophenoxy)ethane
CDD	Compact disk drive
CRT	Cathode ray tube
Chlordecone	Decachloropentacyclodecan-5-one
DBP	Di-n-butylphthalate
DBDPE	Decabromodiphenyl Ethane or Decabromodiphenyl ether
DBT	Dibutyltin
DEHA	Bis(2-ethylhexyl) adipate
DEHP	Diethylhexyl phthalate
DEP	Diethyl phthalate
DEPA	Danish Environment protection agency
DIDP	Diisodecyl phthalate
DINP	Diisononyl phthalate
DMP	Dimethyl phthalate
DNOP	Di-n-octylphthalate
DOC	Dissolved organic carbon
DOT	Dioctyltin
DPs	Dechlorane plus
DPT	Diphenyltin
EPA	Environment protection agency
EH-TBB	2-ethyl-1-hexyl-2,3,4,5-tetrabromobenzoate (same as TBB)
FDD	Floppy disk drive
GC	Gas chromatography
GC-ECD	Gas chromatography - electron capture detector
HBB	Hexabromobenzene
HBCDD	Hexabromocyclododecane
HCDBCO	Hexachlorocyclopentenyldibromocyclooctane
HDD	Hard disk drive
ICP-MS	Inductively coupled plasma mass spectrometry
LC	Liquid-chromatography
LCD	Liquid crystal display
LV	Limit value
MB	Motherboard
MBT	Monobutyltin
MOT	Monooctyltin
MPT	Monophenyltin

MSW	Municipal solid waste
NBFR	Novel brominated flame retardant(s)
OBTMPI	Octabromotrimethylphenyl indane
PAH	Polycyclic aromatic hydrocarbons
PBDE	Polybrominated diphenyl ethers
PBEB	Pentabromoethylbenzene
PCB	Polychlorinated biphenyl
PFAS	Per- and polyfluoroalkyl substances
PFBA	Perfluorobutanoic acid (PFBA)
PFPeA	Perfluoropentanoic acid (PFPeA)
PFHxA	Perfluorohexanoic acid (PFHxA)
PFHpA	Perfluoroheptanoic acid (PFHpA)
PFOA	Perfluorooctanoic acid (PFOA)
PFNA	Perfluorononanoic acid (PFNA)
PFDA	Perfluorodecanoic acid (PFDA)
PFUnDA	Perfluoroundecanoic acid (PFUnDA)
PFDoDA	Perfluorododecanoic acid (PFDoDA)
PFTrDA	Perfluorotridecanoic acid (PFTrDA)
PFBS	Perfluorobutane sulfonic acid (PFBS)
PFPeS	Perfluoropentane sulfonic acid (PFPeS)
PFHxS	Perfluorohexane sulfonic acid (PFHxS)
PFHpS	Perfluoroheptane sulfonic acid (PFHpS)
PFOS	Perfluorooctane sulfonic acid (PFOS)
PFNS	Perfluorononane sulfonic acid (PFNS)
PFDS	Perfluorodecane sulfonic acid (PFDS)
PFUnDS	Perfluoroundecane sulfonic acid (PFUnDS)
PFDoDS	Perfluorododecane sulfonic acid (PFDoDS)
PFTrDS	Perfluorotridecane sulfonic acid (PFTrDS)
6:2 FTS	6:2 Fluorotelomer sulfonic acid (6:2 FTS)
FOSA	Perfluorooctane sulfonamide (FOSA)
QC	Quality criterion (or criteria)
SPLP	Synthetic precipitation leaching procedure (also known as EPA Method 1312) was designed to evaluate the leachability of contaminants from soil and waste samples caused by rainwater of relatively low pH.
TBB	2-ethyl-1-hexyl-2,3,4,5-tetrabromobenzoate (same as EHTBB)
TBBPA	Tetrabromobisphenol A
TBBPA-DBPE	Tetrabromobisphenol A bis(2,3-dibromopropyl ether)
TBP-AE	2,4,6-Tribromophenyl allyl ether
TBP-BAE	2-Bromoallyl 2,4,6-tribromophenyl ether
TBP-DBPE	2,3-Dibromopropyl 2,4,6-tribromophenyl ether
TBPH	bis(2-ethylhexyl) tetrabromophthalate (same as BEHTBP)
TBT	Tributyltin
TCHT	Tricyclohexyltin
TCLP	Standard toxicity characteristic leaching procedure was designed to simulate the worst-case scenario in typical sanitary landfills. It is mainly used by US EPA to classify whether or not a waste material is hazardous according to its toxicity characteristic. TCPL extraction fluid. Note that there are several different fluids in the TCLP.
TDS	Total dissolved solids

TPT	Triphenyltin
TTBT	Tetrabutyltin
WEEE	Waste Electrical and Electronic Equipment
WWTP	Waste water treatment plant

Summary

This report describes the performance and of leaching tests on three different types of WEEE (Waste Electrical and Electronic Equipment):

- Small household appliances including IT and telecommunication items;
- LCD/CRT; and
- Temperature exchange equipment (e.g. refrigerators and freezers).

The aim of the leaching tests was to provide insight into the leaching and potential environmental impacts of metals, metalloids, salts, dissolved organic carbon, polychlorinated biphenyls, phthalates, organotin compounds and brominated flame retardants (with special focus on "novel" brominated flame retardants) during temporary outdoor storage scenarios.

In order to assess whether the leaching from WEEE may cause any environmental issues the measured concentrations observed in the eluates are compared with a number of available "limit values" or "quality criteria". Two different base scenarios were assumed to represent the conditions in the field ranging from sites without any environmental protection measures to sites with a certain level of control and management of the drainage or run-off water:

- Scenario 1: Direct run-off to a surface water receptor from the place where WEEE is collected; furthermore, a distinction is made between "freshwater" (1A) and "marine" (1B) surface water receptors.
- Scenario 2: Run-off to the sewage/rainwater collection system connected to a municipal wastewater treatment plant (WWTP).

It was shown that:

- The leaching of dissolved organic carbon (DOC), chloride, fluoride, bromide, Ba, Cd, Cr, Hg, Ni, Sb, PCB, and a number of phthalates (DMP, DEP, DPB, BBP, DEHP, and DNOP) from all the tested WEEE types is assessed as non-problematic with respect to all the outdoor storage scenarios considered.
- The leaching of As, Pb, Se, Sn, Zn, DEHA and TBT (as well as other organotin compounds) is assessed as potentially problematic with respect to at least one of the outdoor storage scenarios considered. For Zn, it should be noted that the leaching from WEEE is significantly lower than the 90th percentile of Zn concentrations measured in run-off water from Zn-roofs. For Se, DEHA and TBT, it should be noted that they are assessed potentially problematic because of high limit of detection used in this study which is higher than some of the limit values/quality criteria used.

A qualitative screening for brominated flame retardants revealed that:

- TBBPA was detected in all leachate samples (including test blanks). The levels increased in following order: test blanks ≈ leachate from refrigerators and freezers < leachate from LCD/CRT < leachate from small household appliances including IT and telecommunication items.
- PBDEs were detected in many samples at low signal levels, mostly tetra and penta-BDEs.
- BTBPE was found in more than 70% of samples while HBCDD and TBP-AE were occasionally detected as well.

- More than 10 unknown compounds with clear bromine/chlorine patterns were detected in the leachates. Two of the unknown compounds were tentatively identified as $C_{16}H_{14}Br_4O_2$ and $C_6H_3Br_3O$, respectively.

This report was prepared in 2016/17 and was updated in January 2022 in relation to the amendments to Appendix 2 to the Statutory Order No. 1625/2017 on setting environmental objectives, revising environmental quality requirements (limit values) for the metal arsenic (surface run-off water), lead and cadmium (sediment) in the aquatic environment. The Danish Environmental Protection Agency has reassessed the requirements for the three metals on the basis of new and more detailed knowledge of how toxic they are to aquatic organisms.

The results of additional leaching experiments carried out in 2022 with the focus on the release of PFAS showed that the quality requirement value for “PFAS-compounds” (i.e. the sum of 22 PFAS) of 0.1 µg/l (100 ng/l) was exceeded in half of the eluates from small household appliances including IT and telecommunication items and several eluates from LCD/CRT. None of the eluates from refrigerators and freezers exceeded this quality requirement value. On the other hand, the new QC value for the sum of 4 PFAS (PFOA, PFNA, PFHxS, and PFOS) of 0.002 µg/l (2 ng/l) was exceeded in all eluates from all the tested WEEE types.

Sammenfatning

Denne rapport beskriver gennemførelse og resultater af udvaskningsforsøg med tre forskellige typer af WEEE-affald (elektrisk og elektronisk affald), hhv.:

- Små husholdningsapparater (småt udstyr + småt it- og telekommunikationsudstyr)
- Skærme og monitorer (Skærme, monitorer og udstyr indeholdende skærme med en overflade, der er større end 100 cm^2)
- Kølemøbler (udstyr til temperaturudveksling).

Formålet med udvaskningsforsøgene har været at tilvejebringe et datagrundlag vedr. udvaskning og miljøpåvirkning af potentielt problematiske stoffer, herunder metaller, metalloider, salte, opløst organisk kulstof (DOC), PCB, ftalater, organiske tinforbindelser og bromerede flammehæmmere (med særlig fokus på “nye” bromerede flammehæmmere) fra typiske midlertidige udendørs opbevarings- og vejrscenarier for WEEE-affald i Danmark.

Med henblik på at vurdere, om udvaskning fra WEEE-affald kan give anledning til uacceptable påvirkninger af det omgivende miljø, sammenholdes de målte eluatkoncentrationer ved hjælp af nogle risikovurderingsscenarier med en række tilgængelige og gældende "grænseværdier" eller "kvalitetskriterier". Der opstilles to opbevaringsscenarier, som antages at repræsentere de miljøbeskyttelsesmæssige yderpunkter af, hvorledes WEEE-affald i dag opbevares, dvs. fra pladser uden egentlige miljøbeskyttelsesforanstaltninger til pladser med en vis grad af kontrol og styring/håndtering af afløb og afstrømning af nedbør:

- Scenarie1: Direkte afløb af regnvand til overfladevand fra et opsamlingssted hvor WEEE-affald bliver uden overdækning; der skelnes mellem “fersk” (1A) og “marint” (1B) overfladevand.
- Scenarie 2: Afløb til kloak/regnvandsopsamlingssystemer, der er tilkoblet et kommunalt spildevandsrensningsanlæg.

Resultaterne viser følgende:

- Udvaskningen af opløst organisk stof (DOC), klorid, fluorid, bromid, Ba, Cd, Cr, Hg, Ni, Sb, PCB og en række ftalater (DMP, DEP, BBP, DEHP og DNOP) fra alle de testede WEEE-typer vurderes at være miljømæssigt uproblematiske med hensyn til de ovennævnte opbevaringsscenarier.
- Udvaskningen af As, Pb, Se, Sn, Zn, DEHA, og TBT samt andre organotinforbindelser vurderes at være miljømæssigt potentielt problematiske med hensyn til de to opbevaringsscenarier. For Zn skal det bemærkes, at udvaskningen fra WEEE er signifikant lavere end 90%-fraktilen for udvaskning af Zn med regnvand fra Zn-tage. For Se, DEHA og TBT skal det bemærkes, at de er medtaget som potentielt problematiske, selv om koncentrationerne lå under detektionsgrænserne for de kemiske analyser i denne undersøgelse, fordi disse detektionsgrænser var højere end de grænseværdier, de skulle sammenlignes med.

En kvalitativ screening for indhold af bromerede flammehæmmere i eluaterne viste følgende:

- TBBPA blev påvist i alle eluaterne (herunder også eluaterne fra blindtestene). Niveauerne steg i følgende rækkefølge: blindtest ≈ eluater fra kølemøbler < eluater fra skærme og monitorer < eluater fra små husholdningsapparater (småt udstyr + småt it- og telekommunikationsudstyr).

- PBDE blev påvist i mange prøver i lave niveauer, for det meste tetra- og penta-BDE.
- BTBPE blev påvist i mere end 70% af prøverne, mens også HBCDD og TBP-AE lejlighedsvis blev påvist.
- Flere end 10 ukendte forbindelser med tydelige brom/klor-mønstre blev påvist i eluater. To af de ukendte forbindelser blev tentativt identificeret som hhv. $C_{16}H_{14}Br_4O_2$ and $C_6H_3Br_3O$.

Denne rapport blev udarbejdet i 2016/17 og er opdateret i januar 2022 i forhold til ændringerne af bilag 2 til bekendtgørelse om fastlæggelse af miljømål revideres miljøkvalitetskrav (grænseværdier) for metallerne arsen (overfladevand), bly og cadmium (sediment) i vandmiljøet. Miljøstyrelsen har revurderet kravene for de tre metaller på baggrund af ny og mere detaljeret viden om, hvor giftige de er over for vandlevende organismer.

Resultaterne af yderligere udvaskningsforsøg udført i 2022 med fokus på frigivelse af PFAS viste, at grænseværdien for "PFAS-forbindelser" (dvs. summen af 22 PFAS) på 0,1 µg/l (100 ng/l) blev overskredet i halvdelen af eluatprøverne fra små husholdningsapparater (småt udstyr + småt it- og telekommunikationsudstyr) og flere eluatprøver fra skærme og monitorer. Ingen af prøverne fra kølemøbler oversteg denne grænseværdi. Det nye kvalitetskrav for summen af de 4 PFAS (PFOA, PFNA, PFHxS og PFOS) på 0,002 µg/l (2 ng/l) er overskredet i alle eluatprøverne fra alle de testede WEEE-typer.

1. Introduction

1.1 Background and objectives

In order to limit the transfer of potential contaminants into the environment, Annex VIII to Directive 2012/19 / EU (the so-called WEEE Directive) contains “technical requirements” applicable to (i) sites for storage (including temporary storage) of WEEE prior to its treatment and (ii) sites for treatment of WEEE. A criterion of “weatherproof covering for appropriate areas” is given specifically for the storage sites.

The provision of weatherproof covering for appropriate areas will increase costs for collectors and waste management companies. It is, therefore, appropriate to examine whether and when, the weatherproof covering of appropriate areas should be required. It is up to the individual Member States to define "appropriate areas". To ensure a uniform interpretation of the rules, local authorities, as well as waste management companies, have requested an advisory opinion (in Danish “vejledende udtalelse”) on the matter from the Danish Environmental Protection Agency (DEPA).

A recent study by Chalmers University of Technology (Steenari and Hedberg, 2013) showed that the amount of information regarding the occurrence and leaching of “problematic substances” from WEEE stored under standard atmospheric conditions is limited. In turn, based on the limited amount of information, it has not been possible to conclude unambiguously whether outdoor storage of certain types of WEEE without weatherproof covering may or may not present a risk of an unacceptable dispersion of hazardous substances into the environment. Consequently, DEPA has decided to carry out a project aiming at the collection of additional information regarding the leaching of problematic substances (see below) during storage of three specific types of WEEE:

- Small household appliances including IT and telecommunication items;
- LCD/CRT; and
- Temperature exchange equipment (e.g. refrigerators and freezers)

Although the main activity of the project has been the performance of leaching tests on the above WEEE fractions in order to collect data on eluate concentrations of metals, metalloids, salts, dissolved organic carbon, polychlorinated biphenyls, phthalates, organotin compounds and brominated flame retardants (with special focus on “novel” brominated flame retardants), an initial part of the project included a desktop study focused on collection of available (and relevant) literature data.

1.2 Structure of the report

In order to increase the readability of this report, we rely on the use of Annexes. As such, the main report contains only the information, which was assessed by the authors as crucial to the understanding of the context while all other information (e.g. photo documentation, raw analytical data, accredited laboratory reports etc.) is provided in a number of Annexes.

1.3 Additional measurements of PFAS in 2022

In 2022, DEPA has contracted Danish Waste Solutions to carry out a supplementary set of tests focused on expanding the results of the 2016-project with data about the release of per- and polyfluoroalkyl substances (PFAS) from the three specific types of WEEE tested in the original project. The results of these additional tests are presented separately in Appendix 5.

2. Summary of available information

2.1 Summary of available information

2.1.1 Generic literature screening

A summary of available information on the leaching of potentially problematic substance from WEEE was generated at the initial stage of the project. Due to the global character of WEEE, the search was not limited to Danish data.

The following sources were screened for relevant information:

- Publicly available reports by both authorities (e.g. municipalities, national environment protection agencies) and industry.
- The peer-reviewed scientific publications included in the Thomson Reuters “Web-of-Science” databases as well as various conference proceedings.
- Existing publicly available databases of background concentrations of relevant elements/compounds in rainwater and/or run-off water collected from different types of surfaces (e.g. roads, roofs) and different types of areas (e.g. residential areas, industrial areas) primarily in Denmark and Sweden.

In general, the majority of publications on WEEE produced in the last 10-15 years were primarily aiming to map the content and origin of substances of concern (both inorganic and organic) in different types of WEEE (Morf et al., 2007; Ongondo et al., 2011; Lundstedt, 2011) and to describe the technical, environmental and occupational health-related challenges and problems with regard to dismantling, treatment and recycling of resources from WEEE (Lundstedt, 2011; Pizzol et al., 2012; Julander et al., 2014; Zhang and Xu, 2016). The transfer of elements/substances into the environment via leaching, provided that this has ever been in focus, has been investigated primarily with respect to:

- The leaching of substances from landfilled WEEE which has often been placed together with domestic waste, which could lead to increased leaching of metals/non-metals as well as organic compounds (Jang and Townsend, 2003; Horne and Gertsakis, 2006; Li et al., 2009a; Li et al., 2009b; Kiddee et al., 2013; Zhou et al., 2013); and/or
- The (accelerated/enhanced) leaching/recovery of specific substances for commercial recovery of resources (e.g. “rare earth metals” and Pt-group elements) by means of various extraction methods (Schlummer et al., 2006; Zhang and Xu, 2016).

An overview of collected information sources, which do provide some information about the leaching of (any of the following) metals, metalloids, salts and/or organic compounds, is given in Table 2.1.

TABLE 2.1. Results of the literature screening focused on collection of relevant information with respect to the leaching from WEEE

Content / Aim	Set-up	Leaching data	Comment	Reference
Investigation of leaching from WEEE, monitors and white goods	Lysimeter scale set-up, different WEEE types leached separately with the focus on possible leaching during storage	Metals, BFR, phthalates, organotin, PCB	Discussed in detail in section 2.1.2.	(Steenari and Hedberg, 2013)
Dynamic leaching test of PC components (MB, HDD, FDD, CDD)	Tank test design; L/S 4-10 l/kg; step time typically 7-10 days; the entire test period up to 2 years. Both TCLP[1] and SPLP[2] leachant used.	Ag, Al, As, Au, Ba, Be, Cd, Cr, Cu, Fe, Ga, Ni, Pd, Pb, Sb, Se, Sn, Zn	SPLP gave significantly smaller leaching compared to the TCLP	(Li et al., 2009b)
Leaching of metals and PBDE from WEEE in simulated landfill	Lysimeter column test. C1 (MSW), C2 (MSW + 8% intact WEEE), C3 (MSW + 8% of crushed WEEE)	Al, Ba, Be, Cd, Co, Cr, Cu, Ni, Pb, Sb, V. Also, 27 PBDE congeners	Leaching of Al, Ba, Be, Cd, Co, Cr, Cu, Ni, Pb, Sb, V significantly higher in C3 compared to C1. No clear trend observed for PBDEs	(Kiddee et al., 2013)
Transfer of PBDEs from WEEE to aqueous media	A laboratory test using an "end-over-end contactor" filled with crushed plastic fraction separated from WEEE. Distilled water, as well as landfill leachate, were used as leachant	BDE-47, BDE-99, BDE-100, BDE-153, BDE-154, BDE-183, BDE-207, BDE-209	Higher leaching of PBDE was observed at lower pH range. Distilled water gave significantly lower results compared to landfill leachate	(Danon-Schaffer et al., 2013)
Leaching of metals and BFR from printed circuit boards	TCLP and SPLP as a batch test at L/S 20 l/kg	Cu, Zn, Pb, Ni, Cd, BDE-47, BDE-99, BDE-100, BDE-183, BDE-209, TBBPA.	Cu and Pb were the most leachable metals. Penta-BDE dominated in all eluates while high DOC seemed to promote the leaching of BFRs.	(Zhou et al., 2013)
Toxicity assessment of mobile phone parts	Dynamic batch leaching test (L/S 10 l/kg per step) using MQ-water was carried out for phones dismantled into plastics, printed circuit boards, LCDs, and batteries. The leachate renewal rate was 20, 40, 80 and 160 days.	Cr, Cu, Ni, Pb, Zn	The highest leaching observed from printed circuit boards. The order of total cumulative leached amount was Ni > Cr > Zn > Pb	(Yadav et al., 2014)
Leaching of BFR from mixed wastes under simulated landfill conditions	Three lysimeters (60-cm i.d., 450 cm high) were filled with mixed waste (not WEEE) and watered to simulate rainfall at a rate of	PBDE, TBBPA, TBP, HBCD analyzed over 3.5 years.	Higher leaching of BFRs observed from mixed waste with high organic matter and moisture content. Nevertheless, during the 3.5-year experiment,	(Kajiwara et al., 2014)

[1] TCPL extraction fluid contained glacial CH_3CH_2OOH, NaOH and water. pH of this fluid was 4.93 ± 0.05.

[2] SPLP extraction fluid contained 60/40 %-weight H_2SO_4 and $HNO_3$to reagent water. pH was 4.20 ± 0.05.

Content / Aim	Set-up	Leaching data	Comment	Reference
	16.6–75.8 l/month. Tap water was used in this study.		BFR outflow from the lysimeters was less than 0.6% of the total BFRs in the loaded waste	
Leaching of BFR from TV housing plastics in the presence of dissolved humic matter	Batch leaching tests at L/S 100 l/kg with contact time 0.25, 1, 5, and 20 day(s). After each leaching, the leachant was filtered using 1.2 µm glass-fiber filters.	Different PBDEs, different PBBs, TBBPA, HBCD	Solubility of BFRs in the presence of dissolved humic matter increased by a factor of 10 compared to the solubility in distilled water	(Choi et al., 2009)
Impact assessment of WEEE management practices in developing countries through leaching tests	EN 12457-4 (L/S 10 l/kg); TCLP (L/S 20 l/kg); CEN/TS 14429 (pH-static test); and EN 14405 (up-flow percolation test) were carried out with a crushed sample (<10 mm) of printed circuit boards from PCs.	Cu, Pb, Zn, Cr, Cd, Mn, Ni, DOC,	Leaching of all metals (except Cd) strongly dependent on pH. Pb is the most leachable. The leachability pattern of the other metals was in the order of Cd < Zn < Cr < Ni < Mn < Cu regardless of the leaching test conditions. DOC affects the leaching of several metals.	(Ousman, 2015)

As indicated in Table 2.1, the majority of "leaching data" has been obtained in studies whose aim was to characterize the leaching of metals and flame retardants from *landfilled* WEEE items. Hence, a TCLP (Toxicity characteristic leaching procedure) was often used to determine the leaching potential of WEEE. The TCLP approach, however, is only relevant in scenarios where WEEE is co-disposed with biodegradable organic waste (from e.g., ordinary household waste), and the results of these studies cannot be easily translated to the "outdoor storage" scenario which will be investigated in this project.

Several authors have mentioned that the TCLP gives significantly higher leaching than the SPLP (Synthetic Precipitation Leaching Procedure) as well as the leaching obtained by using different types of water (e.g. tap water, demineralised water, etc.). The main reason for the high leaching results obtained by the TCLP is the increased mobility of metals caused by a combined effect of a lower pH of the eluate (many metals are significantly[3] more soluble at acidic conditions) and high content of organic acids in the eluate (organic acids complex with metals thus increase their solubility as well as mobility).

The overall conclusion from the above-mentioned research is that when WEEE is mixed with other waste types – especially the organic waste – in landfills, the substances change their mobility and toxicity. In general, eluate concentrations of both metals and BRFs may increase; however, it is rather difficult to estimate all the environmental impacts since these studies typically did not focus on the mobility of these compounds in the environment.

2.1.2 Study by Chalmers University of Technology

In 2011-2012, Chalmers University of Technology carried out a leaching study whose main objective was to clarify whether WEEE stored under open-air condition (i.e. exposed to rainwater) at recycling stations will leach environmentally harmful elements/compounds (e.g. metals, metalloids, and organic substances) into the run-off water and surrounding environment. As such, the study by the Chalmers University of Technology is – to the best of our knowledge –

[3] The solubility of some metals (e.g. Pb and Cd) can change several orders of magnitude within relatively narrow pH range.

the only study found in the literature with an aim similar to that of the present project (i.e., to characterize the leaching of potential contaminants from WEEE during outdoor temporary storage). Therefore, the results of the study were inspected carefully, and parts of the experimental design used in the present project were inspired by the experience gained by the researchers from Chalmers.

The final report from the Chalmers study (Steenari and Hedberg, 2013) contains, in fact, results of two sub-studies (study 1 and study 2) of the leaching from WEEE. Both studies were conducted in the form of simulated rainwater leaching of WEEE, but with different methods and with different degrees of precision and different analytical programmes. In general, leaching tests were carried out on the three main categories of WEEE: a) mixed electronic waste (e.g. phones, cables, toys, vacuum cleaners and other home electronics); b) Flat-screen TV and older CRTs (the different screen types were tested separately), and c) cooling equipment. Tap water acidified with HNO_3 to pH 5.1 was used as artificial rainwater.

The main observations from the project are summarized in Table 2.2.

TABLE 2.2. Summary of information from the study by Chalmers University of Technology

Parameter	WEEE-type	Main observation
Water	All	The results showed that most of the rainwater that accumulates in a container is “free water”; i.e. it flows out immediately when the container is moved and/or lifted.
TDS	Mixed WEEE	Mixed WEEE gave the highest TDS value (typically 10-25 mg/l, while at several occasions about 100 mg/l was measured). It should be noted that a) TDS is not an environmental parameter, b) the target value storm water in the area is 50 mg/l and c) it was not clear how much of the TDS originated from the (unclean) containers (see below).
	LCD/CRT and cooling equipment	LCD/CRT and the cooling equipment gave lower TDS values compared to the mixed WEEE (above). Typically, about 2-10 mg/l (maximum 23 mg/l) was measured. These values were lower than the target value for TDS in storm water in the area (50 mg/l).
	All	Although WEEE contains dust particles, the TDS values were fairly low. In study 1, the TDS levels were generally higher than in study 2, but this was attributed to the fact that the test containers were not cleaned properly in study 1.
TOC	All	TOC level in leachates (20-50 mg/l) clearly higher than in blanks. In general, $TOC_{mixed\ WEEE} > TOC_{LCD/CRT} > TOC_{cooling\ equipment}$. Different results obtained for study 1 and study 2, which was attributed to the fact that test containers were not cleaned properly in study 1.
PCB	All	PCB in all eluates (only study 2) was found at <0.010 µg/l (LOD).
Organotin compounds	All	MBT, DBT, TBT (only in mixed WEEE and cooling equipment), TTBT (only in cooling equipment), MOT, and DOT were measured. Organotin compounds showed elevated levels compared to the blanks; the maximum concentration found was 4.5 µg/l MBT in an eluate from mixed WEEE. Mixed WEEE and the cooling equipment showed higher leaching compared to the LCD/CRT. It appeared that older products leached more organotin compounds compared to the new products. It was also stated by the authors that the run-off water from waste storage/sorting facilities typically contains 0.1-18 µg/l “organotin” compounds.

Parameter	WEEE-type	Main observation
BFR[4]	All	Mixed WEEE, as well as LCD/CRT, showed the lower release of BFR compared to the cooling equipment. Significant lack of BFR-related data from similar studies was identified as the major obstacle and area of future research.
Phthalates	Mixed WEE	DMP, DEP, DBP, BBP, DEHP, DNOP, DIDP, and DINP were measured. Mixed WEEE showed concentrations of DEHP between 1-10 µg/l (the maximum 71 µg/l).
	LCD/CRT and cooling equipment	The leaching of phthalates from LCD/CRT and cooling equipment was "extremely low" as the majority of results were <0.1 µg/l (LOD for DMP, DEP, DBP, BBP and DNOP) and/or <1 µg/l (LOD for DEHP, DIDP and DINP).
	All	According to the study, DEHP levels between 1-5 µg/l were detected in stormwater from residential areas in Stockholm and Gothenburg while run-off from municipal recycling stations typically shows up to 100 µg/l. It was concluded that the leaching of phthalates from WEEE seems to give leachate levels in the same range as the leaching related to buildings and traffic.
Be	All	The leaching of Be was found <0.50 µg/l (LOD) in all eluates
As	Mixed WEE	The eluate concentrations measured in study 1 were between 100-500 µg/l (with the maximum about 1000 µg/l). During study 2, significantly lower values were observed; in general, the results were <1 µg/l (LOD) with the exception of a couple of eluates showing 10 µg/l as the maximum.
	LCD/CRT and cooling equipment	The eluate concentrations were <1 µg/l (LOD).
Cd	Mixed WEE	The eluate concentrations measured in study 1 were up to 490 µg/l whereas in study 2, the eluate concentrations were typically found <1µg/l (LOD) with a single extreme value of 760 µg/l. Since the higher leaching of Cd was accompanied by higher leaching of Ni it was concluded that the cause for the high release of Cd was NiCd batteries.
	LCD/CRT and cooling equipment	The eluate concentrations were typically <1 µg/l (LOD).
Cr	All	The leaching from empty (metal) test container was 10-35 µg/l. Although the results indicate that a portion of Cr may leach from WEEE during the storage, no conclusive leaching patterns were observed.
	Mixed WEE	The eluate concentrations measured in study 1 were 10-90 µg/l whereas, in study 2, 0-20 µg/l was typically found.
	LCD/CRT	The eluate concentrations were typically between 2 and 12 µg/l.
	cooling equipment	The eluate concentrations were typically less than 10 µg/l. Single test unit showed release up to 70 µg/l.
Cu	Mixed WEE	The leaching of Cu was always higher than 9 µg/l and typically below 500 µg/l, but eluates exceeding 1000 µg/l were found occasionally.
	LCD/CRT	The eluate concentrations were typically between 20 and 200 µg/l.
	cooling equipment	The eluate concentrations were typically between 20 and 150 µg/l. Several test units showed release up to 250-350 µg/l.
Ni	Mixed WEE	The leaching of Ni did not appear to be related to the metal containers used during the test. Solution concentration of Ni was typically measured between 80 and 270 µg/l while the highest leaching was observed from the mixed WEEE; in this case, over 1000 µg/l Ni were measured and this result was concluded to be caused by leaching from NiCd batteries.

[4] PBDE 207, Tot-NonaBDE, PBDE 209 and HBCD were measured

Parameter	WEEE-type	Main observation
	LCD/CRT	The eluate concentrations were typically between 10 and 30 µg/l; occasionally 40-50 µg/l were measured.
	cooling equipment	The eluate concentrations were typically significantly less than 10-20 µg/l; one test unit showed release up to 100-120 µg/l.
Pb	Mixed WEE	The majority of eluates showed Pb concentrations above 3 µg/l. At some occasions, the leaching of Pb reached 20-80 µg/l.
	LCD/CRT	The eluate concentrations were typically below 5 µg/l (flat screens) and 40-120 µg/l (CRTs).
	cooling equipment	Highly variable results ranging from 1 to 35-45 µg/l.
Sb	Mixed WEE	The eluate concentrations were typically between 1 and 120 µg/l.
	LCD/CRT	The eluate concentrations were typically between 5 and 20 µg/l (flat screens) and 10-40 µg/l (CRTs).
	cooling equipment	The eluate concentrations were typically <1 µg/l (LOD).
Zn	All	The lowest value measured in the eluates was 600 µg/l.
	Mixed WEE	The eluate concentrations typically between 1000 and 15000 µg/l. At single occasion 30000 µg/l was measured.
	LCD/CRT	The eluate concentrations were typically around 1000 µg/l (CRTs) and between 1300 and 8000 µg/l (flat screens).
	cooling equipment	The eluate concentrations were typically between 600 and 2000 µg/l while at several occasions up to 4000-5000 µg/l were measured.

The overall conclusions from the project by the Chalmers University of Technology are:

- The extreme heterogeneity of the WEEE and the physical conditions of the individual items (e.g. broken vs. not broken) plays an important role in the leaching during storage; as such, the results of the study “may be seen more as trends rather than exact values”.
- Cooling equipment does not have to be covered during the storage period (up to one month), whereas the mixed WEEE should not be exposed to the rain.
- WEEE does not retain any significant volume of water; the majority of the rainwater runs out when the container is moved.

More specific conclusions are listed below:

- The highest levels of TDS (predominantly “dust”) were observed in eluates from mixed WEEE
- The leaching of PCB is insignificant (below LOD 0.010 µg/l).
- The leaching of organotin compounds is insignificant; MBT is the only organotin detected in measurable concentrations.
- The leaching of BFR may be relevant in the case of the cooling equipment and should be investigated further.
- The leaching of phthalates may be relevant in the case of mixed WEEE; nevertheless, the observed levels were of the same order of magnitude as found in typical surface run-off water from residential areas.
- The eluate from mixed WEEE typically has Cu, Ni, Pb and Zn concentrations above the local target values for drainage water.
- The lowest leaching of Zn was 600 µg/l while results in the range of 5000-15000 µg/l were common.
- Significantly more Zn seemed to leach from “flat screens” as compared to CRTs whereas the opposite was observed for Cu, Pb, and Sb; no clear trend was observed for Ni.

2.2 Further remarks

On one hand, the literature screening confirmed that there is some information available regarding the release of potentially problematic elements/substances from WEEE when disposed of in

landfills. On the other hand, the literature screening also confirmed that there is a very limited amount of information available regarding the leaching of potentially problematic elements /substances from WEEE during the intermediate open-air storage scenarios (e.g. at collection stations and/or recycling centres prior to the processing).

The results (or better yet experience) reported by Steenari and Hedberg (2013) who carried out two studies on the subject of leaching from WEEE during storage were discussed and summarized in the previous section. Here, it should be stated that results from different studies are not directly comparable since these studies are not carried out in a standardized manner which would ensure reproducibility (e.g. different items are tested, the physical conditions (degree of damage) of these items vary, the contact time between the solid phase and the percolating liquid is random, etc.). As such, Steenari and Hedberg (2013) concluded that their results should be seen as “trends and not as exact values”.

3. Materials and methods

3.1 Selected WEEE types

Three leaching tests were carried out at Stena (Brøndby), which in total took a little over six weeks. The tested WEEE-types were:

- "Mixed-WEEE"; herein primarily small household appliances (e.g. microwave oven, blenders, boiling kettles and alike), computers, telephones etc.
- LCDs/CRTs
- Freezers/refrigerators

During the initial stage of the project, Stena has been consulted regarding the practical issues related to the collection of the WEEE items which were planned to be used in the leaching tests. The tender documentation specifically stated that the tested items must not have been exposed to rain prior to the testing. This could be rather problematic to ensure, especially in the case of refrigerators, freezers and "screens", if these were collected from recycling stations since bulky items such as refrigerators and freezers are normally collected in large metal containers and exposed to rain. Similarly, "screens" are typically collected in the open and not under a roof. Mixed WEEE, on the other hand, is typically collected in metal cages which are placed indoor or under roof, hence generally not exposed to rainwater.

It was agreed with Stena that they would provide a number of containers/cages containing refrigerators, freezers, "screens" and a number of containers/cages containing "small WEEE" which were collected directly from different companies (i.e. they were picked up at the company and never went through a municipal recycling station). These cages were then inspected by the project team and items which are typically found in the "mixed WEEE" collected at the recycling stations were combined into the test sample used in the test container. Similarly, LCDs/CRTs and freezers/refrigerators were collected and placed in test containers.

The number and type of individual items placed in the test containers are given in Table 3.1.

TABLE 3.1. List of WEEE items used in the leaching test

	Leaching test		
Item description	**"Mixed-WEEE"**	**"LCDs/CRTs"**	**"Freezers/Refrigerators"**
Computer	2	-	-
Water boiling kettle	4	-	-
Rice cooker	1	-	-
Iron	3	-	-
Blender	2	-	-
Printer/scanner	3	-	-
Vacuum cleaner	1	-	-
VCR/DVD player	3	-	-
Computer keyboard	3	-	-
Computer mouse	1		
Calculator	1	-	-
Notebook/laptop	2	-	-

	Leaching test		
Item description	**“Mixed-WEEE”**	**“LCDs/CRTs”**	**“Freezers/Refrigerators”**
Microwave oven	1	-	-
Fax/telephone	4	-	-
Coffee machine	1	-	-
Toaster	1	-	-
APC Battery backup	1	-	-
Home foot spa machine	1	-	-
Bathroom scale	1	-	-
Modem	1	-	-
Cell phone	1	-	-
LCD screen	-	14	-
CRT screen	-	2	-
Refrigerator (only)	-	-	3
Refrigerator + freezer	-	-	3
Items, total count	**38**	**16[a]**	**6**
Weight, net (kg)	**119**	**98**	**300**

[a)] The ratio 7:1 between LCDs and CRTs reflects the current proportion of these items as received by Stena (Stena, personal communication).

A graphical overview of the individual items is provided as part of the photo documentation in Appendix 1.

It should be noted that none of the items used in the leaching test with “Mixed WEEE” and “LCDs/CRTs” appeared broken (physically) or disintegrated. The only exception was a PC chassis which was “open” and thus the inner components (e.g. motherboard, ventilator, and energy unit) were exposed. As for the “Freezers/Refrigerators”, there were five items with front doors and one item without a front door. No visible leaks from the cooling system were observed while a significant amount of dust was collected on the condensers on the back side of all items.

3.2 Design of the leaching experiment

3.2.1 Test containers

All leaching experiments were carried out in an industry hall at Stena, Brøndby.

The first two of the three tests were carried out in 1000 L HDPE containers (IBC container with the top cut off) while the freezer/refrigerator) leaching test was carried out in a medium size metal container (Figure 3.1). The test containers with “Mixed-WEEE”, LCDs/CRTs, and freezers/refrigerators (= freezers/fridges) will henceforth be referred to as “M”, “L” and “F/F”, respectively.

All test containers were equipped with an outlet valve at the bottom and were slightly tilted towards the outlet valve in order to facilitate the collection of eluate and to ensure that there will be limited eluate build-up between the individual irrigation events.

Empty test containers (1000 L HDPE)

HDPE test containers with a dust cover

Metal test container with a dust cover

As mentioned in the report by the Chalmers University of Technology, a part of their results was "questionable" because of potential contamination of the eluates by the test containers. In our study, both HDPE containers (M and L) and the metal container (F/F) were rinsed thoroughly with water using a high-pressure washer before they are filled with tested WEEE items. In addition, blank tests were carried out for each type of container (discussed further in section 3.2.3). Finally, to prevent contamination with dust, all test containers were covered using a plastic sheet during the entire test period. The only exception was when water was added to the system during the individual irrigation events (see next section).

3.2.2 Irrigation scheme and sample collection

All three leaching tests (M, L, and F/F) were carried out in a similar matter (Table 3.2).

TABLE 3.2. Irrigation scheme

Parameter	Units	M	L	F/F
Test container	-	HDPE	HDPE	metal
Rain: "normal"	mm	40	40	40
Rain: "extreme"	mm	160	160	160
Irrigated surface	m2	1.0	1.0	1.9
Volume: "normal"	litres per event	40	40	76
Volume: "extreme"	litres per event	160	160	304

First, the material in each test container was irrigated once a week with a predefined quantity of water which was equal to 40 l/m2; i.e., one-fourth of the 160 mm/month precipitation which corresponds to the wettest month in the typical year. The 40 mm irrigation was referred to as “normal”. The eluate from each “normal” irrigation (#1 to #4) was collected from the bottom of the test container the following day and sent to the analytical laboratory immediately. This set-up simulated up to 4 weeks of storage (with 4 individual rain events) without shelter prior to the collection. Next, the containers were lifted and moved around using a front loader and/or a fork lifter in order to “shake” the items a little (simulating transport). After being lowered again, the containers were irrigated after one week with an amount of water corresponding to the “normal” event (i.e., 40 mm precipitation), hence generating eluate #5. Then, after another week, the material in each test container was irrigated at once with a volume of water equivalent to one of the later year’s “extreme” rainfalls (i.e., 160 mm). The eluate (#6) was collected from the bottom of the container the next day and sent to the analytical laboratory immediately.

A portion of eluates intended for screening for novel brominated flame retardants (NBFR) was stored at approximately 4 °C during the entire test period and then sent to the analytical laboratory in the UK in a single shipment.

In should be noted tap water was used during the first irrigation of M and L (M-1, L-1). However, the tap water showed rather high levels of several metals and it was therefore decided to switch to deionized water (DW) which was used from #2 to #6 in M and L while all eluates from the F/F (F/F-1 to F/F-6) were obtained using deionized water.

3.2.3 Eluate analysis

Quantitative analysis

An overview of the analytical methods is provided in Table 3.3 together with the limit of detection (LOD) of the individual parameters.

TABLE 3.3. Overview of the analytical program

Parameter	LOD (µg/l)	Method	Instrument
Metals and metalloids			
As	0.2	EN ISO 17294-2: 2005	ICP-MS
Ba	10	EN ISO 17294-2: 2005	ICP-MS
Be	0.5	EN ISO 17294-2: 2005	ICP-MS
Cd	0.03	EN ISO 17294-2: 2005	ICP-MS
Cr	0.3	EN ISO 17294-2: 2005	ICP-MS
Cu	0.5	EN ISO 17294-2: 2005	ICP-MS
Hg	0.03	SS EN 1483	ICP-MS
Pb	0.2	EN ISO 17294-2: 2005	ICP-MS
Ni	0.5	EN ISO 17294-2: 2005	ICP-MS
Se	2	EN ISO 17294-2: 2005	ICP-MS
Sb	0.2	EN ISO 17294-2: 2005	ICP-MS
Zn	3	EN ISO 17294-2: 2005	ICP-MS
Li	5	EN ISO 17294-2: 2005	ICP-MS
Sn	0.1	EN ISO 17294-2: 2005	ICP-MS
Salts and DOC			
Chloride	1000	SS-EN ISO 10304-1: 2009	LC
Bromide	1000	SS-EN ISO 10304-1: 2009	LC
Fluoride	50	SS-EN ISO 10304-1: 2009	LC

Parameter	LOD (µg/l)	Method	Instrument
DOC	330	SS-EN 1484 ed. 1	TOC analyser
Phthalates			
Dimethyl phthalate (DMP)	1	extraction with hexane	GC-MS
Diethyl phthalate (DEP)	1	extraction with hexane	GC-MS
Di-n-butylphthalate (DBP)	1	extraction with hexane	GC-MS
Benzylbutylphthalate (BBP)	1	extraction with hexane	GC-MS
Bis(2-ethylhexyl) adipate (DEHA)	1	extraction with hexane	GC-MS
Diethylhexyl phthalate (DEHP)	1	extraction with hexane	GC-MS
Di-n-octylphthalate (DNOP)	1	extraction with hexane	GC-MS
Dimethyl phthalate (DMP)	1	extraction with hexane	GC-MS
Polychlorinated biphenyls			
PCB-28	0.001	internal method by Alcontrol	GC-ECD
PCB-52	0.001	internal method by Alcontrol	GC-ECD
PCB-101	0.001	internal method by Alcontrol	GC-ECD
PCB-118	0.001	internal method by Alcontrol	GC-ECD
PCB-128	0.001	internal method by Alcontrol	GC-ECD
PCB-153	0.001	internal method by Alcontrol	GC-ECD
PCB-180	0.001	internal method by Alcontrol	GC-ECD
PCB7, sum	0.007	calculated	
Organotin compounds			
Tributyltin (TBT)	0.02	ISO/DIS 23161:2007 mod.	GC
Triphenyltin (TPT)	0.02	ISO/DIS 23161:2007 mod.	GC
Monobutyltin (MBT)	0.02	ISO/DIS 23161:2007 mod.	GC
Dibutyltin (DBT)	0.02	ISO/DIS 23161:2007 mod.	GC
Monophenyltin (MPT)	0.02	ISO/DIS 23161:2007 mod.	GC
Diphenyltin (DPT)	0.01	ISO/DIS 23161:2007 mod.	GC
Tricyclohexyltin (TCHT)	0.01	ISO/DIS 23161:2007 mod.	GC

As noted in the previous section, during each sampling six portions of eluate were collected from each test container in order to be subjected to the different analytical packages indicated in Table 3.3. However, not all eluates were analyzed for all the parameters listed. When selecting the number of eluates and analytical parameters to be screened in those eluates, results/experience from the study by Chalmers university of Technology were used. For example, it was decided not to analyse PCB in all eluates, since their data indicated that the leaching of PCB from WEEE is insignificant. On the other hand, it was decided to focus on BFR since these compounds were suggested as relevant for further investigation.

All eluates were analysed for metals/metalloids, salts, DOC, organotin and BFR. The analytical programmes for each eluate sample are shown in Table 3.4 to Table 3.6.

TABLE 3.4. Overview of the different parameters determined in eluates from M

Parameters measured in M-eluates	M-1	M-2	M-3	M-4	M-5	M-6
Metals + metalloids	x	x	x	x	x	x
Salts + DOC	x	x	x	x	x	x
Phthalates	x	x	x	x	x	x
Organotin	x	x	x	x	x	x
PCB	x	x		x		x
NBFR	x	x	x	x	x	x

TABLE 3.5. Overview of the different parameters determined in eluates from L

Parameters measured in L-eluates	L-1	L-2	L-3	L-4	L-5	L-6
Metals + metalloids	x	x	x	x	x	x
Salts + DOC	x	x	x	x	x	x
Phthalates	x	x				x
Organotin	x	x	x	x	x	x
PCB	x	x		x		x
NBFR	x	x	x	x	x	x

TABLE 3.6 Overview of the different parameters determined in eluates from F/F

Parameters measured in F/F-eluates	F/F-1	F/F-2	F/F-3	F/F-4	F/F-5	F/F-6
Metals + metalloids	x	x	x	x	x	x
Salts + DOC	x	x	x	x	x	x
Phthalates	x	x				x
Organotin	x	x	x	x	x	x
PCB	x	x		x		x
NBFR	x	x	x	x	x	x

In addition, a number of blank tests and water samples were analyzed in order to obtain information about background levels (Table 3.7). A blank test was carried out using the same container, deionized water, the same irrigation scheme and the same sample collection. The only difference was missing WEEE.

TABLE 3.7. Overview of the different parameters determined in blanks and water samples

Parameters	tap water[a]	DW[b] (#1)	DW (#2)	Blank L/M	Blank F/F
Metals + metalloids	x	x	x	x	x
Salts + DOC	x	x	x	x	x
Phthalates				x	x
Organotin				x	x
PCB				x	x
NBFR				x	x

[a)] Tap water available in the industry hall at Stena, Brøndby. The tap water was used only in M-1 and L-1; all other eluates were degenerated using deionized water (DW) provided by Scion DTU in Hørsholm.

[b)] Deionized water.

Qualitative screening for brominated flame retardants (BFR)
Qualitative screening for BFR was carried out by the University of Birmingham. The screening focused particularly on the so-called “novel” BFR (NBFR). There is no uniform definition of “novel” BFRs. For the purpose of this report, the NBFR are defined as BFRs which are new to the market or newly/recently observed in the environment. Important representatives of this group are DBDPE, BTBPE, TBB (or EHTBB), TBPH (or BEHTBP), TBBPA-DBPE, and HCDBCO (Covaci et al., 2011).

In this project, all leachates were screened for the presence of predefined BFRs (i.e. a targeted screening), as well as for other BFRs (i.e. an untargeted screening).

The *targeted* screening was carried out for BFRs which are listed in Table 3.8.

TABLE 3.8. Flame retardants included in the in-house mass library.

Substance	Abbreviation
Polybrominated diphenyl ethers	PBDEs
Hexabromocyclododecane	HBCDD
Tetrabromobisphenol A	TBBPA
2,4,6-Tribromophenyl allyl ether	TBP-AE
2-Bromoallyl 2,4,6-tribromophenyl ether	TBP-BAE
2,3-Dibromopropyl 2,4,6-tribromophenyl ether	TBP-DBPE
Pentabromoethylbenzene	PBEB
Hexabromobenzene	HBB
Brominated biphenyl 153	BB-153
1,2-Bis(2,4,6-tribromophenoxy)ethane	BTBPE
2-Ethylhexyl 2,3,4,5-tetrabromobenzoate	EH-TBB
Bis(2-ethylhexyl) tetrabromophthalate	BEH-TEBP
Hexachlorocyclopentenyldibromocyclooctane	HCDBCO
Octabromotrimethylphenyl indane	OBTMPI
Decachloropentacyclodecan-5-one	Chlordecone
Dechlorane plus	DPs

During the *untargeted* screening, the Compound Discoverer data analysis software was configured to detect unknown compounds with a maximum chemical formula $C_{40}H_{60}Br_{15}Cl_{10}O_{10}$. Bromine patterns with up to 12 bromines were configured for pattern matching.

For further details about methods, sample preparation and instruments used during the BFR screening refer to Appendix 2.7.

3.3 Leaching data assessment and overview of limit values

In order to assess whether the leaching from WEEE may cause any environmental issues the measured concentrations observed in the eluates are compared with a number of available “limit values” (henceforth referred to as LV) or “quality criteria” (henceforth referred to as QC).

In general, the assessment should account for a number of different storage scenarios and, consequently, for a number of discharge scenarios. Here, two different base scenarios were assumed to represent the conditions in the field ranging from sites without any environmental protection measures to sites with a certain level of control and management of the drainage or run-off water. Basically, the following scenarios are assumed:

- Scenario 1: Direct run-off to a surface water receptor from the place where WEEE is collected; furthermore, a distinction is made between "freshwater" (1A) and "marine" (1B) surface water receptors
- Scenario 2: Run-off to the sewage/rainwater collection system connected to a municipal wastewater treatment plant (WWTP)

For Scenarios 1A/1B the QC for maximum concentrations of elements in the different type of receptor (freshwater vs. marine) defined in the Statutory Order No. 1625/2017 apply whereas for Scenario 2 the LVs defined in Table 2.5.1 of "Tilslutningsvejledningen"[5] apply. However, note that the QC from the Statutory Order No. 1625/2017[6] should be complied with in the receptor and *not* at the point of discharge. Since an impact is likely to occur over a longer period of time at a relatively constant level (because new WEEE is constantly supplied), the "General QC" are chosen rather than the "Maximum QC". Usually, LVs at the point of discharge to a sewage system (Scenario 2) are calculated by multiplying the QC with a factor 20, which is used to account for "partial degradation and certain initial dilution"[7].

Here, a so-called tiered approach will be used to evaluate the eluate concentrations with respect to Scenario 1A/1B:

- First, a QC from the Statutory Order No. 1625/2017 will be used *without* multiplication; this first level assessment provides a most conservative (stringent) form of an assessment and if all elements complied with this most conservative assessment, the evaluation would stop.
- If any element exceeded the most conservative value, the QC would be multiplied by a factor of 10, which has often been used as a "rule of thumb" for discharge into surface water bodies, to provide a "more realistic" (yet still rather conservative) form of an assessment (Hjelmar and Henriksen, 2015).
- If any element exceeded the QC x 10 value, this element should be considered as "potentially problematic" and possibly investigated further. In the present situation, it could lead to a recommendation that the type of WEEE in question should not be exposed to percolating rainwater that is subsequently allowed to run off without any control.

A summary of the available QCs (extracted from the Statutory Order No. 1625/2017) or LVs (extracted from "Tilslutningsvejledningen") is provided in Table 3.9.

As mentioned in Section 1.3, in 2022 DEPA has contracted Danish Waste Solutions to carry out a supplementary set of tests focused on expanding the results of the 2016-project with data about the release of per- and polyfluoroalkyl substances (PFAS) from the three specific types of WEEE tested in the original project. The experimental design and used analytical methods are presented separately in Appendix 5.

[5] Vejledning fra Miljøstyrelsen Nr. 2, 2006: Tilslutning af industrispildevand til offentlige spildevandsanlæg. www2.mst.dk/Udgiv/publikationer/2006/87-7052-055-0/pdf/87-7052-055-0.pdf

[6] https://www.retsinformation.dk/eli/lta/2017/1625

[7] This approach is described on page 32 of "Tilslutningsvejledningen".

TABLE 3.9. Overview of "limit values" (i.e. quality criteria as well as limit values) applicable with respect to evaluation of solution concentrations measured in eluates from WEEE in two different discharge/run-off scenarios: Scenario 1 (based on the Statutory Order No. 1625/2017) and Scenario 2 (based on "Tilslutningsvejledningen").

Parameter	Scenario 1: Direct discharge to surface water receptors				Scenario 2
	General QC		General QC x 10		LV for discharge to a sewer/WWTP
	1A: Fresh-water	1B: Marine water	1A: Fresh-water	1B: Marine water	
pH					6.5-9.0
As, µg/l	4.3 [a]	0.6[a]	43	6	13
Ba, µg/l	19 [a]	5.8 [a]	190	58	
Be, µg/l					
Cd, µg/l	0.08	0.2	0.8	2	3
Cr, µg/l	3.4	3.4	34	34	300
Cu, µg/l	4.9	4.9	49	49	100
Hg, µg/l	0.07 [c]	0.07 [c]	0.07 [c]	0.07 [c]	3
Pb, µg/l	1.2	1.3	12	13	100
Ni, µg/l	4	8.6	40	86	250
Se, µg/l	0.1 [a]	0.08 [a]	1	0.8	8
Sb, µg/l	113	11.3	1130	113	
Zn, µg/l	7.8 [a,b]	7.8 [a]	78	78	3000
Li, µg/l					
Sn, µg/l	2	0.2	20	2	60
Cl, mg/l					1000
Br, mg/l					
F, mg/l					
DOC, mg/l					
DMP, µg/l					
DEP, µg/l					
DBP, µg/l	2.3	0.23	23	2.3	
BBP, µg/l	7.5	0.75	75	7.5	
DEHA, µg/l	0.7	0.07	7	0.7	
DEHP, µg/l	1.3	1.3	13	13	7
DNOP, µg/l					
PCB-28, µg/l					
PCB-52, µg/l					
PCB-101, µg/l					
PCB-118, µg/l					
PCB-138, µg/l					
PCB-153, µg/l					
PCB-180, µg/l					
PCB7, sum, µg/l					
TBT, µg/l	0.0002	0.0002	0.002	0.002	
TPT, µg/l					
MBT, µg/l					
DBT, µg/l					
MPT, µg/l					

Parameter	Scenario 1: Direct discharge to surface water receptors				Scenario 2
	General QC		General QC x 10		LV for discharge to a sewer/WWTP
	1A: Fresh-water	1B: Marine water	1A: Fresh-water	1B: Marine water	
DPT, µg/l					
TCHT, µg/l					

[a] Maximum concentration added to the natural background concentration.

[b] The QC applies to the “bioavailable” fraction of the element.

[c] There is no QC set for Hg, only the maximum concentration; cf. the Statutory Order No. 1625/2017.

4. Results and discussion

4.1 Results of the blank tests and background screenings

Blank tests were carried out for the HDPE test container used in L test[8] and for the metal container used in the F/F test.

It was originally planned to use tap water (available in the hall at Stena, Brøndby) as the leachant in the leaching tests and it was, in fact, used to generate M-1 and L-1 eluates. However, during the initial stage of the leaching test, it turned out that the concentration level of some parameters in the tap water was similar to or higher than that observed in the study by Chalmers University. Consequently, the tap water was replaced by DW produced at a large scale deionisation unit at DTU Scion in Hørsholm. The DW was used in both blank tests, all F/F eluates (F/F-1 to F/F-6) and all M/L eluates except for M-1 and L-1. It should be noted that although the DW had lower contents of Ba, Cd, Ni, Sb, Li, and Zn, it also showed a surprisingly high level of Cu. The sample was re-measured (same result) and a new water sample was taken and analysed (same result). At this moment, it is not clear whether Cu has passed through the deionisation unit or whether it is caused by Cu-containing parts in the water distribution line after the deionisation unit.

The results of the eluate analysis of the individual parameters are shown in Appendix 2 in the corresponding tables. In addition, the results are summarized in Table 4.1 together with the results of the water analysis (tap water and DW).

TABLE 4.1. Results of the eluate analysis for blank tests and different water types

Parameter	Blank-L	Blank-F/F	Tap water	DW
pH	7.1	7.3	7.8	6.8
conductivity, mS/m	2.53	4.55	97.2	1.79
As, µg/l	*<0.2*	0.46	<0.2	<0.2
Ba, µg/l	*<10*	65	44	<10
Be, µg/l	*<0.5*	*<0.5*	<0.5	<0.5
Cd, µg/l	*<0.03*	0.12	0.034	<0.03
Cr, µg/l	*<0.3*	0.5	<0.3	<0.3
Cu, µg/l	51	42	2	83
Hg, µg/l	*<0.03*	*<0.03*	<0.03	<0.03
Pb, µg/l	2.3	6.3	4.4	4.4
Ni, µg/l	0.5	1.1	12	<0.5
Se, µg/l	*<2*	*<2*	<2	<2
Sb, µg/l	*<0.2*	0.8	0.29	<0.2
Zn, µg/l	190	120	2400	92
Li, µg/l	10	*<5*	27	<5
Sn, µg/l	*<0.1*	0.8	<0.1	<0.1
Cl, mg/l	1.6	2.7	94	-
Br, mg/l	*<1*	*<1*	1	-
F, mg/l	*<0.05*	0.056	0.57	-

[8] Two identical HDPE test containers were used in the course of the project for M and L, respectively.

Parameter	Blank-L	Blank-F/F	Tap water	DW
DOC, mg/l	*<0.3*	0.89	2.2	-
Dimethyl phthalate (DMP), µg/l	*<1*	*<1*	-	-
Diethyl phthalate (DEP), µg/l	*<1*	*<1*	-	-
Di-n-butylphthalate (DBP), µg/l	*<1*	*<1*	-	-
Benzylbutylphthalate (BBP), µg/l	*<1*	*<1*	-	-
Bis(2-ethylhexyl) adipate (DEHA), µg/l	*<1*	2.1	-	-
Diethylhexyl phthalate (DEHP), µg/l	*<1*	*<1*	-	-
Di-n-octylphthalate (DNOP), µg/l	*<1*	*<1*	-	-
PCB-28, µg/l	0.0025	*<0.001*	-	-
PCB-52, µg/l	0.0018	*<0.001*	-	-
PCB-101, µg/l	*<0.001*	0.001	-	-
PCB-118, µg/l	*<0.001*	*<0.001*	-	-
PCB-138, µg/l	*<0.001*	0.0011	-	-
PCB-153, µg/l	*<0.001*	*<0.001*	-	-
PCB-180, µg/l	*<0.001*	*<0.001*	-	-
PCB7, sum, µg/l	*<0.007*	*<0.007*	-	-
Tributyltin (TBT), µg/l	*<0.02*	*<0.02*	-	-
Triphenyltin (TPT), µg/l	*<0.02*	*<0.02*	-	-
Monobutyltin (MBT), µg/l	0.04	*<0.02*	-	-
Dibutyltin (DBT), µg/l	*<0.02*	*<0.02*	-	-
Monophenyltin (MPT), µg/l	*<0.02*	*<0.02*	-	-
Diphenyltin (DPT), µg/l	*<0.1*	*<0.1*	-	-
Tricyclohexyltin (TCHT), µg/l	*<0.02*	*<0.02*	-	-

It can be seen from Table 4.1 that:

- The metal container (F/F) showed – expectedly – higher leaching of e.g. As, Ba, Cd, Cr, Pb, Ni, Sb, Sn and DOC compared to the plastic containers (both L and M); this observation is consistent with higher measured conductivity in F/F eluates compared with L eluates.
- Blank tests gave similar or higher results of most metals/metalloids than measured in the DW; the only clear exception was Cu (discussed previously).
- The leaching of organic compounds (DOC, phthalates, PCBs, and organotin) from either type of test containers was negligible.

4.2 Results of leaching tests and scenario-based assessments

4.2.1 General

In the following sections, the results of the leaching tests are presented as solution concentrations measured in the individual eluates (in µg/l or mg/l). In many cases, the concentration of an analyte was either below the limit of detection (LOD) or within the so-called limit of quantification (LOQ) which can be vaguely defined as value that is 3 times higher than LOD. Based on an agreement between the project team and DEPA, all results which are below LOQ (i.e. <3xLOD) are henceforth approached as “highly uncertain” and treated equally to LOD provided they do not conflict with QC and/or LVs.

As mentioned in Section 1.3, in 2022 DEPA has contracted Danish Waste Solutions to carry out a supplementary set of tests focused on expanding the results of the 2016-project with data about the release of per- and polyfluoroalkyl substances (PFAS) from the three specific types of WEEE tested in the original project. The results of these additional measurements are presented and discussed separately in Appendix 5.

4.2.2 Release of metals and metalloids

The leaching of metals and metalloids from the three test containers is tabulated in Appendix 2.2 together with the results of the blank tests (background) carried out for both the HDPE containers and the metal containers.

The leaching of Be and Br was below their LODs, 0.5 µg/l and 1 µg/l, respectively. Since there are neither QC nor LVs available for these compounds in Scenarios 1A/1B and Scenario 2 these elements are neither shown graphically nor discussed further in this section. The leaching of Hg and Se was also found below their LODs: 0.03 µg/l and 2 µg/l, respectively. Nevertheless, since there are QC and/or LVs available for these elements, they will be discussed further.

Arsenic (As)

The general QC for As in Scenario 1A and Scenario 1B are 4.3 µg/l and 0.6 µg/l, respectively. The LV for As applicable in Scenario 2 is 13 µg/l.

As shown in Figure 4.1 and summarised Table 4.2, the leaching of As from Mixed WEEE (M) and LCDs/CRTs (L) complied with the general QC for Scenario 1A and Scenario 1B while this value was exceeded in eluates from Freezers/Fridges (F/F). The LV for Scenario 2 was complied with in the case of L and M while it was exceeded in case of F/F.

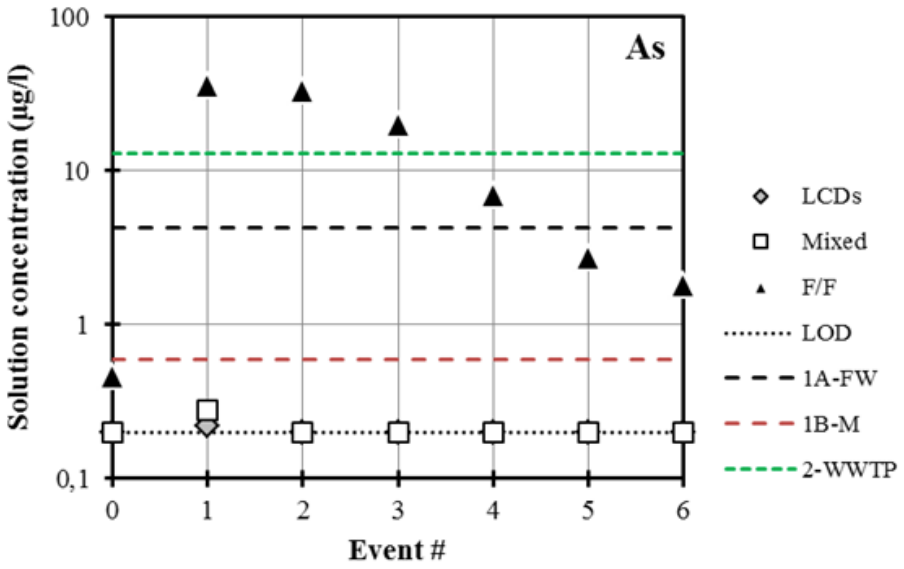


FIGURE 4.1. Solution concentrations of As in eluates from three different tests with WEEE compared to QC and LV.

TABLE 4.2. Results of the 1st level assessment for As.

	Scenario 1A (freshwater)	Scenario 1B (marine)	Scenario 2 (sewer to WWTP)
QC; LV	4.3 µg/l	0.6 µg/l	13 µg/l
Mixed WEEE	passed	passed	passed
LCD/CRT	passed	passed	passed
F/F	**exceeded**	**exceeded**	**exceeded**

The high leaching of As (between 36 and 1.8 µg/l) from F/F was rather surprising[9] and significantly higher than the results of the blank test carried out for the metal container (0.46 µg/l) which suggests that the contribution from the container itself might be limited. Furthermore, the shape of the leaching curve points to the release of readily available As (e.g. present in dust collected in the condenser?) rather than a contribution from the metallic material of the fridge (or the surface paint?). Because of the design of the leaching test, it is not possible to conclude whether the leaching of As was caused by a single item or by more items.

Using the multiplication factor 10 (cf. section 3.3) results in respectively $QC_{freshwater}$ x 10 = 43 µg/l and QC_{marine} x 10 = 6 µg/l (Table 3.9). The leaching from all WEEE types would comply with the $QC_{freshwater}$ x 10 whereas the QC_{marine} x 10 would still be exceeded in eluates from F/F (Table 4.3).

TABLE 4.3. Results of the 2nd level assessment for As.

	Scenario 1A x 10 (freshwater)	**Scenario 1B x 10 (marine)**	**Scenario 2 (sewer to WWTP)**
QC x 10; LV	43 µg/l	6 µg/l	13 µg/l
Mixed WEEE	passed	passed	passed
LCD/CRT	passed	passed	passed
F/F	passed	**exceeded**	**exceeded**

Based on this, the leaching of **As** from the F/F is evaluated as **potentially problematic** for the considered outdoor storage **Scenario 1B** (direct discharge to a marine receptor) and **Scenario 2** (discharge to a sewer/WWTP). Consequently, it is recommended that F/F should not be exposed to percolating rainwater that is subsequently allowed to run off without any control.

To estimate the exact impact from the leaching of As from F/F a dedicated scenario calculation needs to be carried out in order to account for scenario-specific dilution and attenuation in the transport phase. Furthermore, it may be beneficial to carry out additional (more detailed) tests on the release of As from different parts of F/F items, which would confirm (or reject) the trends observed in this study.

Barium (Ba)

The general QC for Ba in Scenario 1A and Scenario 1B are 19 µg/l and 5.8 µg/l, respectively. There is no LV applicable for Scenario 2.

As shown in Figure 4.2 and Table 4.4, the leaching of Ba from all types of WEEE exceeded the general QC for both Scenario 1A and Scenario 1B.

[9] Steenari and Hedberg (2013) reported the leaching of As at "<1 µg/l" for "refrigerators and freezers".

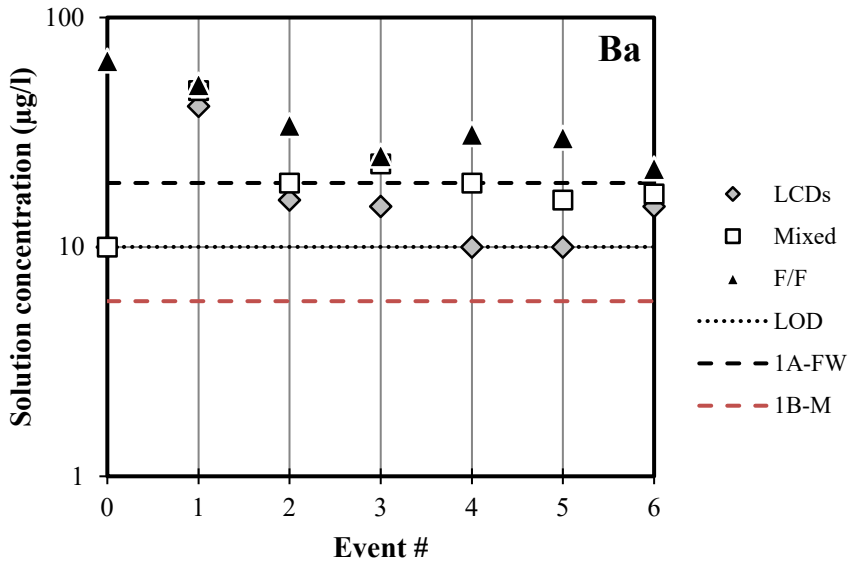


FIGURE 4.2. Solution concentrations of Ba in eluates from three different tests with WEEE compared to QC

TABLE 4.4. Results of the 1st level assessment for Ba.

	Scenario 1A (freshwater)	Scenario 1B (marine)	Scenario 2 (sewer to WWTP)
QC; LV	19 µg/l	5.8 µg/l	-
Mixed WEEE	**exceeded**	**exceeded**	-
LCD/CRT	**exceeded**	**exceeded**	-
F/F	**exceeded**	**exceeded**	-

Using the multiplication factor 10 (cf. section 3.3) results in respectively $QC_{freshwater}$ x 10 = 190 µg/l and QC_{marine} x 10 = 58 µg/l (Table 3.8). The leaching from all WEEE types would comply with both the $QC_{freshwater}$ x 10 and the QC_{marine} x 10 since the only eluate exceeding the QCs is the F/F-blank[10] (Table 4.5).

TABLE 4.5. Results of the 2nd level assessment for Ba.

	Scenario 1A x 10 (freshwater)	Scenario 1B x 10 (marine)	Scenario 2 (sewer to WWTP)
QC x 10; LV	190 µg/l	58 µg/l	-
Mixed WEEE	passed	passed	-
LCD/CRT	passed	passed	-
F/F	passed	passed	-

Based on this, the leaching of **Ba** from the three types of WEEE tested in this project is assessed as **non-problematic** in relation to the outdoor storage scenarios considered.

[10] i.e. there seems to be a non-negligible contribution to the leaching of Ba from the metal container.

Cadmium (Cd)

The general QC for Cd in Scenario 1A and Scenario 1B are 0.08 µg/l and 0.2 µg/l, respectively. The LV for Cd applicable in Scenario 2 is 3 µg/l.

As shown in Figure 4.3 and summarised in Table 4.6, the leaching of Cd from L and M exceeded the general QC for both the Scenario 1A and the Scenario 1B while the leaching from F/F exceeded the general QC for Scenario 1A and complied with the general QC for Scenario 1B. The leaching from all WEEE types complied with LV for Scenario 2.

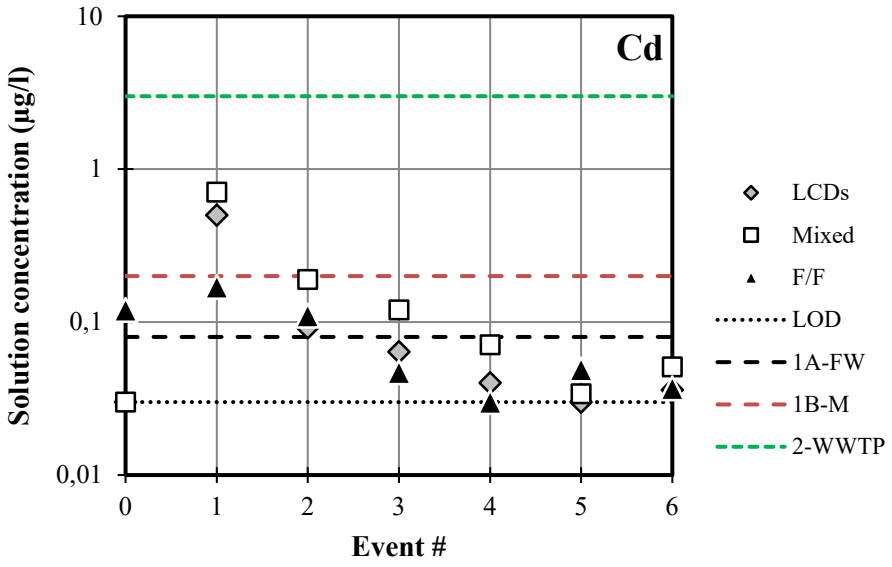


FIGURE 4.3. Solution concentrations of Cd in eluates from three different tests with WEEE compared to QC and LV.

TABLE 4.6. Results of the 1st level assessment for Cd.

	Scenario 1A (freshwater)	**Scenario 1B (marine)**	**Scenario 2 (sewer to WWTP)**
QC; LV	0.08 µg/l	0.2 µg/l	3 µg/l
Mixed WEEE	**exceeded**	**exceeded**	passed
LCD/CRT	**exceeded**	**exceeded**	passed
F/F	**exceeded**	passed	passed

Using the multiplication factor 10 (cf. section 3.3) results in respectively $QC_{freshwater}$ x 10 = 0.8 µg/l and QC_{marine} x 10 = 2 µg/l (Table 3.8). The leaching from all WEEE types would comply with both the $QC_{freshwater}$ x 10 and the QC_{marine} x 10 (Table 4.7).

TABLE 4.7 Results of the 2nd level assessment for Cd.

	Scenario 1A x 10 (freshwater)	**Scenario 1B x 10 (marine)**	**Scenario 2 (sewer to WWTP)**
QC x 10; LV	0.8 µg/l	2 µg/l	3 µg/l
Mixed WEEE	passed	passed	passed
LCD/CRT	passed	passed	passed
F/F	passed	passed	passed

Based on this, the leaching of **Cd** from the three types of WEEE tested in this project is assessed as **non-problematic** in relation to the outdoor storage scenarios considered.

Chromium (Cr)

The general QC for Cr in both Scenario 1A and Scenario 1B is 3.4 µg/l (indicated as "1A/B*" in below figure) while the LV for Cr applicable in Scenario 2 is 300 µg/l.

With respect to the general QC for Cr it may be noted that although Cr is likely present as Cr^{III} (e.g. $Cr(OH)_3$) between pH 4 and 8 (at redox potential between -0.4 to 0.9 V) we assumed that Cr will be present in its more problematic hexavalent form and therefore the QC for Cr^{VI} were used. Note however, that the difference between general QC for Cr^{VI} and Cr^{III} is rather small: 3.4 µg/l vs 4.9 µg/l, respectively.

As shown in Figure 4.4 and summarised in Table 4.8, the leaching of Cr from L and F/F complied with the general QC for Scenario 1A/1B while the leaching from M exceeded it. The leaching from all WEEE types complied with the LV for Scenario 2.

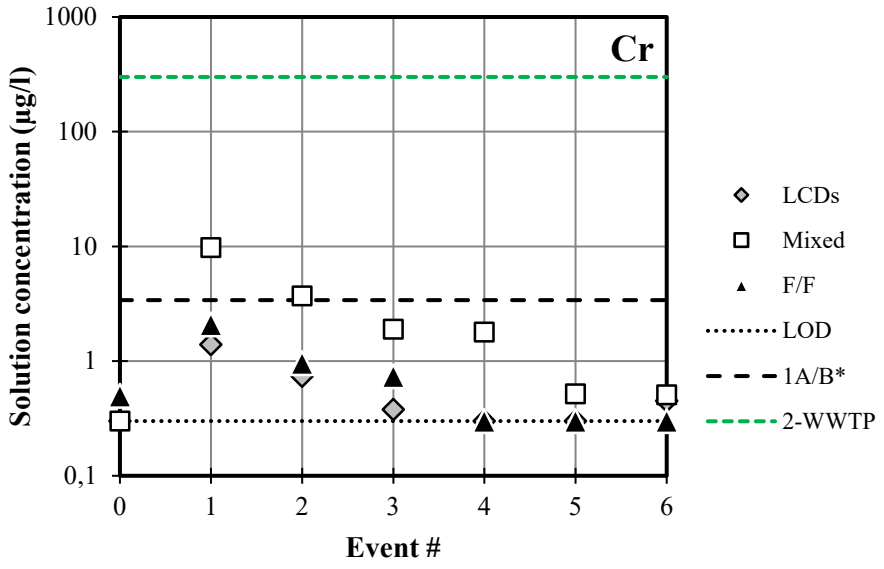


FIGURE 4.4. Solution concentrations of Cr in eluates from three different tests with WEEE compared to QC and LV.

TABLE 4.8. Results of the 1st level assessment for Cr.

	Scenario 1A (freshwater)	Scenario 1B (marine)	Scenario 2 (sewer to WWTP)
QC; LV	3.4 µg/l	3.4 µg/l	300 µg/l
Mixed WEEE	**exceeded**	**exceeded**	passed
LCD/CRT	passed	passed	passed
F/F	passed	passed	passed

Using the multiplication factor 10 (cf. section 3.3) results in $QC_{freshwater}$ x 10 = 34 µg/l; the same value applies for QC_{marine} x 10 (Table 3.8). The leaching from all WEEE types complies with the QC x 10 (Table 4.9).

TABLE 4.9. Results of the 2nd level assessment for Cr.

	Scenario 1A x 10 (freshwater)	Scenario 1B x 10 (marine)	Scenario 2 (sewer to WWTP)
QC x 10; LV	34 µg/l	34 µg/l	300 µg/l
Mixed WEEE	passed	passed	passed
LCD/CRT	passed	passed	passed
F/F	passed	passed	passed

Based on this, the leaching of **Cr** from the three types of WEEE tested in this project is assessed as **non-problematic** in relation to the outdoor storage scenarios considered.

Copper (Cu)

The general QC for Cu in both Scenario 1A and Scenario 1B is 4.9 µg/l (indicated as "1A/B*" in below figure) while the LV for Cu applicable in Scenario 2 is 100 µg/l. As shown in Figure 4.5 and Table 4.10, the leaching of Cu from all types of WEEE exceeded the general QC for Scenario 1A/1B while the leaching from F/F exceeded the LV for Scenario 2.

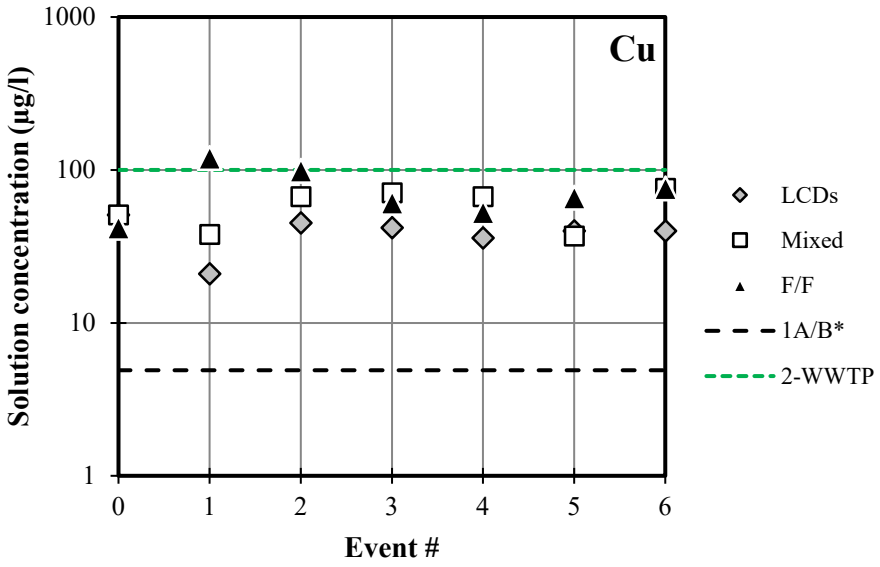


FIGURE 4.4. Solution concentrations of Cu in eluates from three different tests with WEEE compared to QC and LV.

TABLE 4.10. Results of the 1st level assessment for Cu.

	Scenario 1A (freshwater)	Scenario 1B (marine)	Scenario 2 (sewer to WWTP)
QC; LV	4.9 µg/l	4.9 µg/l	100 µg/l
Mixed WEEE	**exceeded**	**exceeded**	passed
LCD/CRT	**exceeded**	**exceeded**	passed
F/F	**exceeded**	**exceeded**	**exceeded**

Using the multiplication factor 10 (cf. section 3.3) results in $QC_{freshwater}$ x 10 = 49 µg/l; the same value applies for QC_{marine} x 10 (Table 3.8). The leaching from L complies with the QC x 10 while the leaching from both M and F/F exceeded this value (Table 4.11).

TABLE 4.11. Results of the 2nd level assessment for Cu.

	Scenario 1A x 10 (freshwater)	Scenario 1B x 10 (marine)	Scenario 2 (sewer to WWTP)
QC x 10; LV	49 µg/l	49 µg/l	100 µg/l
Mixed WEEE	**exceeded**	**exceeded**	passed
LCD/CRT	passed	passed	passed
F/F	**exceeded**	**exceeded**	**exceeded**

Based on this, the leaching of **Cu** from the M and F/F is evaluated as **potentially problematic** in relation to outdoor storage scenarios considered. “Potentially” because, in spite of the high level of Cu in used DW (cf. section 4.1), it is not possible to simply subtract the Cu measured in DW from the results of leaching test since the solution concentrations observed in the leachate may result from different equilibrium-controlled processes. Consequently, it is recommended that M and F/F should not be exposed to percolating rainwater that is subsequently allowed to run off without any control.

Mercury (Hg)

The maximum concentration for Hg in both the Scenario 1A and the Scenario 1B is 0.07 µg/l while the LV for Hg applicable in Scenario 2 is 3 µg/l.

Except for a single eluate (0.049 µg/l) the leaching of Hg was found below the LOD (0.03 µg/l) and thus complying with the maximum concentration for Scenario 1A/1B and Scenario 2 (see Table 4.12).

TABLE 4.12 Results of the 1st level assessment for Hg.

	Scenario 1A (freshwater)	Scenario 1B (marine)	Scenario 2 (sewer to WWTP)
Maximum concentration; LV	0.07 µg/l	0.07 µg/l	3 µg/l
Mixed WEEE	passed	passed	passed
LCD/CRT	passed	passed	passed
F/F	passed	passed	passed

Based on this, the leaching of **Hg** from the three types of WEEE tested in this project is assessed as **non-problematic** in relation to the outdoor storage scenarios considered.

Lead (Pb)

The general QC for Pb in Scenario 1A and Scenario 1B are 1.2 µg/l and 1.3 µg/l, respectively. The LV for Pb applicable in Scenario 2 is 100 µg/l.

As shown in Figure 4.6 and summarised in Table 4.13, the leaching of Pb from all types of WEEE exceeded the general QC for both the Scenario 1A and the Scenario 1B while the LV for Scenario 2 were complied with.

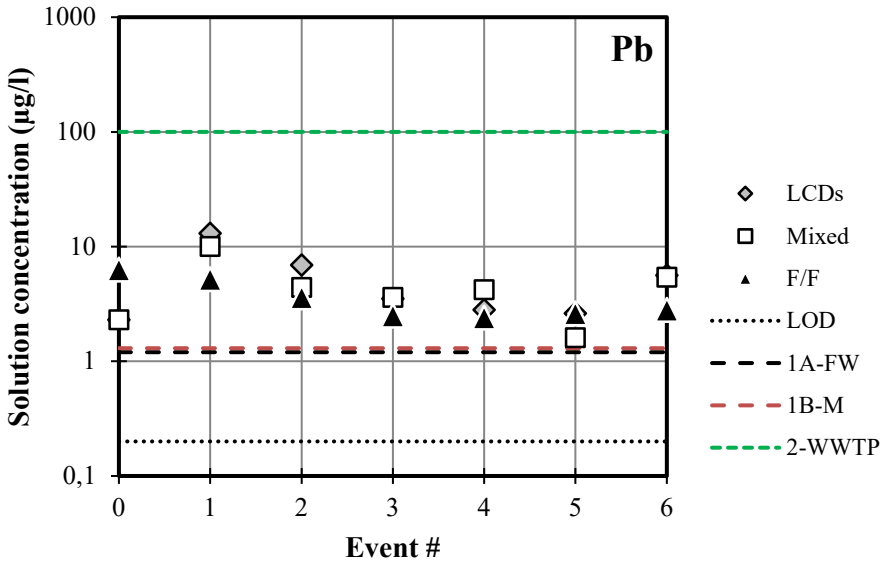


FIGURE 4.5. Solution concentrations of Pb in eluates from three different tests with WEEE compared to QC and LV.

TABLE 4.13. Results of the 1st level assessment for Pb.

	Scenario 1A (freshwater)	Scenario 1B (marine)	Scenario 2 (sewer to WWTP)
QC; LV	1.2 µg/l	1.3 µg/l	100 µg/l
Mixed WEEE	**exceeded**	**exceeded**	passed
LCD/CRT	**exceeded**	**exceeded**	passed
F/F	**exceeded**	**exceeded**	passed

Using the multiplication factor 10 (cf. section 3.3) results in respectively $QC_{freshwater}$ x 10 = 12 µg/l and QC_{marine} x 10 = 13 µg/l (Table 3.8). The leaching from F/F and M would comply with either QC. The leaching from L (L-1 = 13 µg/l) would (i) exceed the QC x 10 for Scenario 1A and (ii) equal the QC x 10 for Scenario 1B (Table 4.14).

TABLE 4.14. Results of the 2nd level assessment for Pb.

	Scenario 1A x 10 (freshwater)	Scenario 1B x 10 (marine)	Scenario 2 (sewer to WWTP)
QC x 10; LV	12 µg/l	13 µg/l	100 µg/l
Mixed WEEE	passed	passed	passed
LCD/CRT	**exceeded**	passed	passed
F/F	passed	passed	passed

Based on this, the leaching of **Pb** from the L is assessed as **potentially problematic** in relation to outdoor storage **Scenario 1A** (direct discharge to a freshwater receptor). Consequently, it is recommended that L should not be exposed to percolating rainwater that is subsequently allowed to run off without any control.

Nickel (Ni)

The general QC for Ni in Scenario 1A and Scenario 1B are 4 µg/l and 8.6 µg/l, respectively. The LV for Ni applicable in Scenario 2 is 250 µg/l.

As shown in Figure 4.7 and summarised in Table 4.15, the leaching of Ni from F/F complied with the general QC for Scenario 1B while it exceeded the general QC for Scenario 1A (in F/F-1 eluate). The leaching of Ni from L and M exceeded the general QC for both the Scenario 1A and the Scenario 1B. The leaching of Ni from all three WEEE types complied with the LV for Scenario 2.

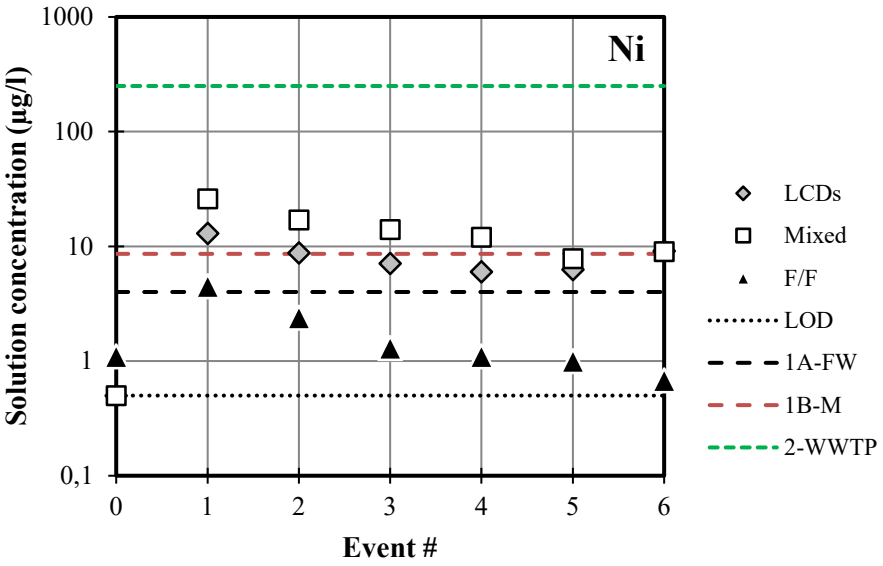


FIGURE 4.6. Solution concentrations of Ni in eluates from three different tests with WEEE compared to QC and LV.

TABLE 4.15. Results of the 1st level assessment for Ni.

	Scenario 1A (freshwater)	Scenario 1B (marine)	Scenario 2 (sewer to WWTP)
QC; LV	4 µg/l	8.6 µg/l	250 µg/l
Mixed WEEE	**exceeded**	**exceeded**	passed
LCD/CRT	**exceeded**	**exceeded**	passed
F/F	**exceeded**	passed	passed

Using the multiplication factor 10 (cf. section 3.3) results in respectively $QC_{freshwater}$ x 10 = 40 µg/l and QC_{marine} x 10 = 86 µg/l (Table 3.8). The leaching of Ni from all three WEEE types complies with the QC x 10 (Table 4.16).

TABLE 4.16. Results of the 2nd level assessment for Ni.

	Scenario 1A x 10 (freshwater)	Scenario 1B x 10 (marine)	Scenario 2 (sewer to WWTP)
QC x 10; LV	40 µg/l	86 µg/l	250 µg/l
Mixed WEEE	passed	passed	passed
LCD/CRT	passed	passed	passed

	Scenario 1A x 10 (freshwater)	Scenario 1B x 10 (marine)	Scenario 2 (sewer to WWTP)
F/F	passed	passed	passed

Based on this, the leaching of **Ni** from the three types of WEEE tested in this project is assessed as **non-problematic** in relation to the outdoor storage scenarios considered.

Selenium (Se)

The general QC for Se in Scenario 1A and Scenario 1B are 0.1 µg/l and 0.08 µg/l, respectively. The LV for Se applicable in Scenario 2 is 8 µg/l.

The leaching of Se in eluates from all three WEEE types collected in the course of this project was below the LOD of 2 µg/l; thus complying with the LV for Scenario 2. Unfortunately, the general QC for Scenario 1A and Scenario 1B are significantly lower than the LOD of the analytical instrument used in this case. Even after using the multiplication factor 10 (cf. section 3.3) which would result in respectively $QC_{freshwater}$ x 10 = 1 µg/l and QC_{marine} x 10 = 0.8 µg/l (Table 3.8), the LOD is higher than these QC values. Hence, based on the precautionary principle, the leaching of **Se** from all three WEEE types is assessed as **possibly problematic** in relation to the outdoor storage scenarios considered. Consequently, unless proven otherwise[11], it is not recommended that any of the tested WEEE types are exposed to percolating rainwater that is subsequently allowed to run off without any control (Table 4.17).

TABLE 4.17. Results of the 2nd level assessment for Se

	Scenario 1A (freshwater)	Scenario 1B (marine)	Scenario 2 (sewer to WWTP)
QC x 10; LV	1 µg/l	0.8 µg/l	8 µg/l
Mixed WEEE	**exceeded by LOD**	**exceeded by LOD**	passed
LCD/CRT	**exceeded by LOD**	**exceeded by LOD**	passed
F/F	**exceeded by LOD**	**exceeded by LOD**	passed

[11] e.g. a dedicated leaching test with eluate analyses with significantly lower LOD.

Antimony (Sb)

The general QC for Sb in Scenario 1A and Scenario 1B are 113 µg/l and 11.3 µg/l, respectively. There is no LV for Sb applicable to Scenario 2.

As shown in Figure 4.8 and summarised in Table 4.18, the leaching of Sb from all three types of WEEE complied with the QC Scenario 1A and Scenario 1B.

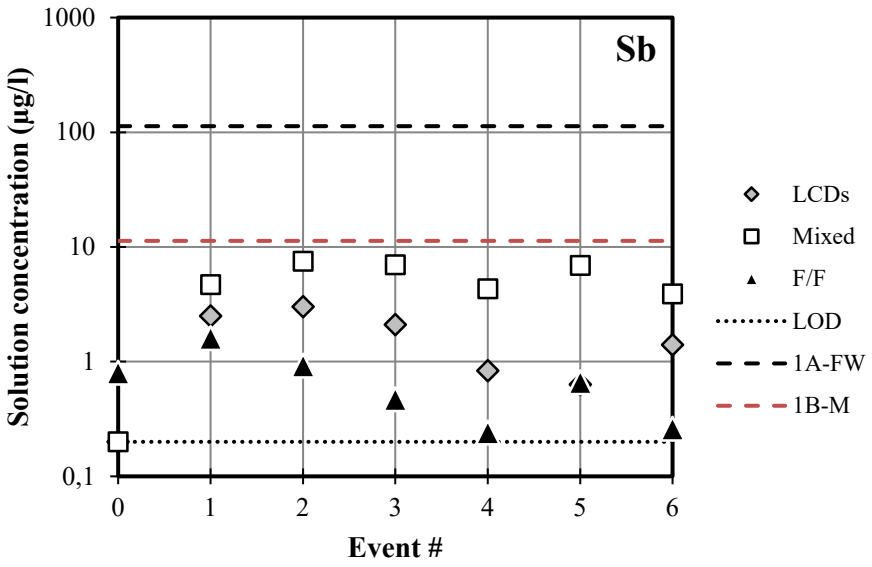


FIGURE 4.7. Solution concentrations of Sb in eluates from three different tests with WEEE compared to QC and LV.

TABLE 4.18. Results of the 1st level assessment for Sb.

	Scenario 1A (freshwater)	Scenario 1B (marine)	Scenario 2 (sewer to WWTP)
QC; LV	113 µg/l	11.3 µg/l	-
Mixed WEEE	passed	passed	-
LCD/CRT	passed	passed	-
F/F	passed	passed	-

Based on this, the leaching of **Sb** from all three types of WEEE tested in this project is assessed as **non-problematic** in relation to the outdoor storage scenarios considered.

Zinc (Zn)

The general QC for Zn in both Scenario 1A and Scenario 1B is 7.8 µg/l (indicated as "1A/B*" in Figure 4.9) while the LV for Zn applicable to Scenario 2 is 3000 µg/l.

As shown in Figure 4.9 and summarised in Table 4.19, the leaching of Zn from all three types of WEEE exceeded the QC for Scenario 1A/1B. Furthermore, the leaching of Zn from M and L was shown to be fairly close to (or exceeding) the LV for Scenario 2. The leaching of Zn from F/F complied with the LV for Scenario 2 (Figure 4.9)

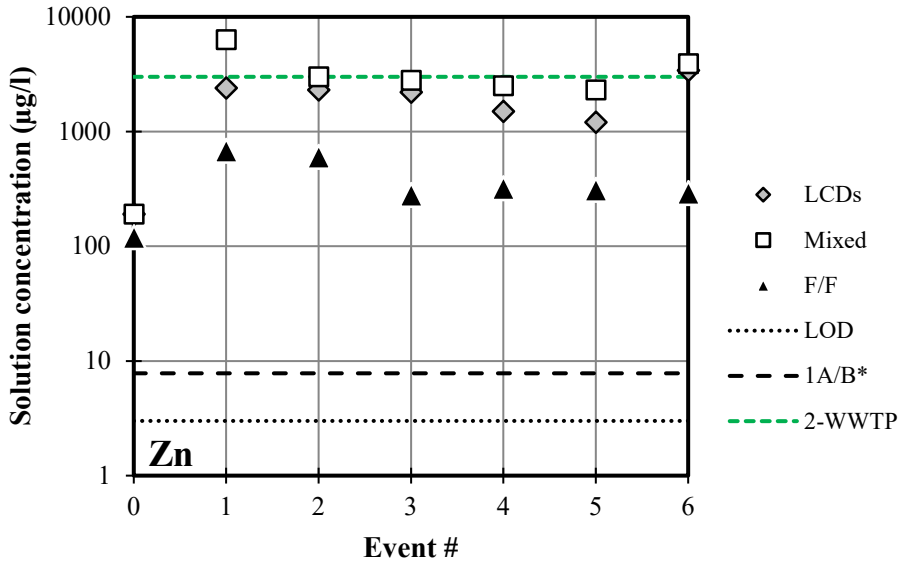


FIGURE 4.8. Solution concentrations of Zn in eluates from three different tests with WEEE compared to QC and LV.

TABLE 4.19. Results of the first level assessment for Zn.

	Scenario 1A (freshwater)	Scenario 1B (marine)	Scenario 2 (sewer to WWTP)
	7.8 µg/l	7.8 µg/l	3000 µg/l
Mixed WEEE	**exceeded**	**exceeded**	**exceeded**
LCD/CRT	**exceeded**	**exceeded**	**exceeded**
F/F	**exceeded**	**exceeded**	passed

Using the multiplication factor 10 (cf. section 3.3) results in $QC_{freshwater}$ x 10 = 78 µg/l; the same value applies to QC_{marine} x 10 (Table 3.8). The leaching of Zn from all three WEEE types would exceed the QC x 10 (Table 4.20) even if the contributions from the test containers and the used DW (about 120-190 µg/l) were subtracted[12].

TABLE 4.20. Results of the 2nd level assessment for Zn

	Scenario 1A x 10 (freshwater)	Scenario 1B x 10 (marine)	Scenario 2 (sewer to WWTP)
QC x 10; LV	78 µg/l	78 µg/l	3000 µg/l
Mixed WEEE	**exceeded**	**exceeded**	**exceeded**
LCD/CRT	**exceeded**	**exceeded**	**exceeded**
F/F	**exceeded**	**exceeded**	passed

The leaching of Zn observed from the tested WEEE is comparable to or actually lower than the levels observed by Steenari and Hedberg (2013) and comparable with the Zn levels observed in runoff from “waste management facilities such as recycling stations and shredder plants”, as discussed in detail in section 4.3. Note also that runoff from zinc-plated roofs shows about 2-3 times higher levels of Zn; i.e., ~8600 µg/l at the 90th percentile level as also discussed in section 4.3.

[12] Which is generally not recommended as discussed for Cu earlier.

Based on this, the leaching of **Zn** from the three types of WEEE tested in this project is assessed as **potentially problematic**[13] in relation to the outdoor storage scenarios considered. Consequently, it is not recommended that any of the three tested WEEE types are exposed to percolating rainwater that is subsequently allowed to run off without any control.

Lithium (Li)

There are no QC and/or LV for Li applicable to any of the scenarios considered.

As shown in Figure 4.10, the leaching of Li from F/F was below the LOD of 5 µg/l at all occasions. The leaching of Li from respectively L and M reached the maximum of 28 µg/l and 24 µg/l and then decreased to below 10 µg/l (M) or below LOD (L). The observed leaching of Li from L and M is attributed to the use of tap water (27 µg/l of Li) in the first leaching step and its replacement with deionized water (DW) which was used from #2 to #6 in M and L while all eluates from the F/F (F/F-1 to F/F-6) were obtained using deionized water.

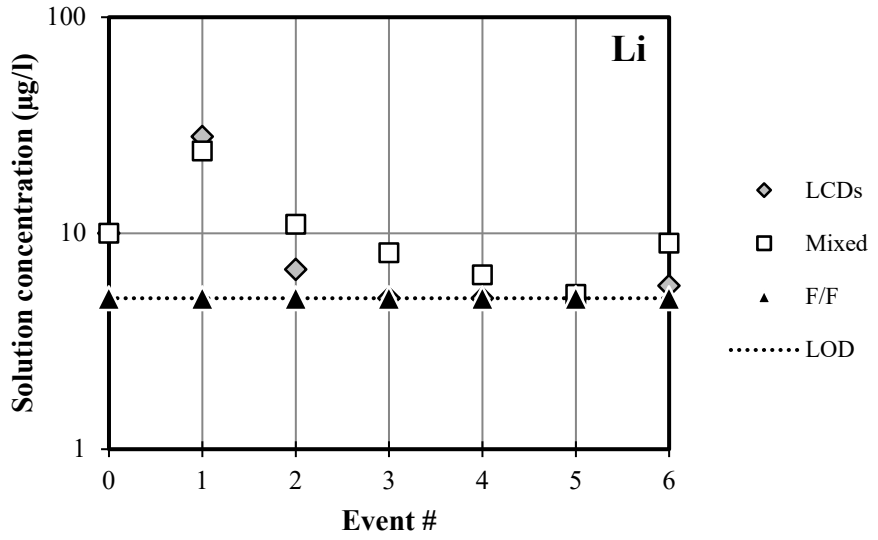


FIGURE 4.9. Solution concentrations of Li in eluates from three different tests with WEEE.

Based on this, the leaching of **Li** from the three types of WEEE tested in this project is assessed as **non-problematic** in relation to the outdoor storage scenarios considered.

Tin (Sn)

The general QC for Sn in Scenario 1A and Scenario 1B are 2 µg/l and 0.2 µg/l, respectively. The LV for Sn applicable to Scenario 2 is 60 µg/l.

As shown in Figure 4.11 and summarised in Table 4.21, the leaching of Sn from all three types of WEEE exceeded the general QC for Scenario 1B. Furthermore, the leaching of Sn from L and M exceeded the general QC for Scenario 1A; the leaching from F/F complied with this QC. Leaching from all WEEE types complied with the LV for Scenario 2.

[13] Provided that run-off from Zn roofs is considered problematic too.

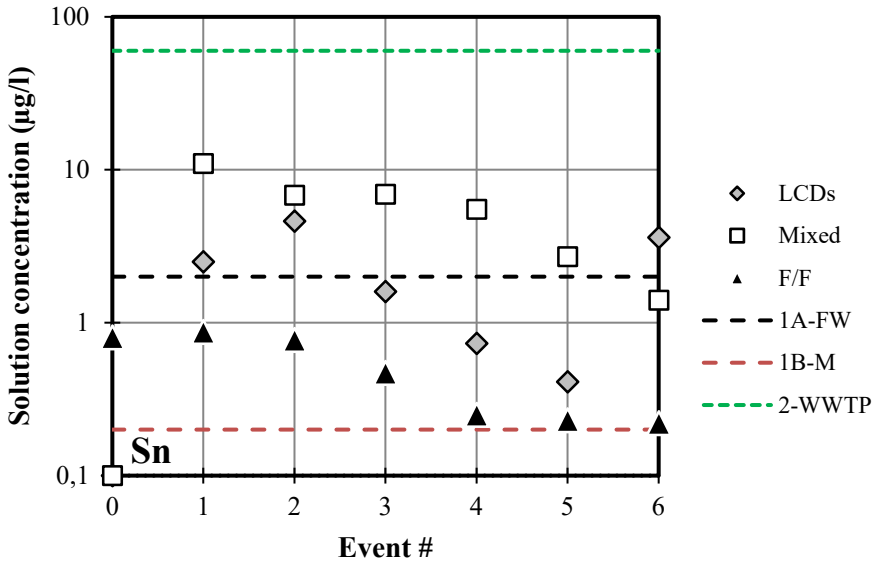


FIGURE 4.10. Solution concentrations of Sn in eluates from three different tests with WEEE compared to QC and LV.

TABLE 4.21. Results of the 1st level assessment for Sn.

	Scenario 1A (freshwater)	Scenario 1B (marine)	Scenario 2 (sewer to WWTP)
QC; LV	2 µg/l	0.2 µg/l	60 µg/l
Mixed WEEE	**exceeded**	**exceeded**	passed
LCD/CRT	**exceeded**	**exceeded**	passed
F/F	passed	**exceeded**	passed

Using the multiplication factor 10 (cf. section 3.3) results in respectively $QC_{freshwater}$ x 10 = 20 µg/l and QC_{marine} x 10 = 2 µg/l (Table 3.8). Consequently, the leaching of Sn from F/F would comply with the QC x 10 for Scenario 1B while the leaching from L and M would still exceed this QC x 10 for Scenario 1B. The leaching from all three WEEE types would comply with the QC for Scenario 1A (Table 4.22).

TABLE 4.22. Results of the 2nd level assessment for Sn.

	Scenario 1A (freshwater)	Scenario 1B (marine)	Scenario 2 (sewer to WWTP)
QC x 10; LV	20 µg/l	2 µg/l	60 µg/l
Mixed WEEE	passed	**exceeded**	passed
LCD/CRT	passed	**exceeded**	passed
F/F	passed	passed	passed

Based on this, the leaching of **Sn** from the three types of WEEE tested in this project is assessed as **non-problematic** in relation to **Scenario 1A** (direct discharge to a freshwater receptor) and **Scenario 2** (discharge to sewer/WWTP). On the other hand, the leaching of **Sn** is assessed as **potentially problematic** in relation to **Scenario 1B** (direct discharge to a marine receptor). Consequently, it is not recommended that M/L WEEE-type is exposed to percolating rainwater that is subsequently allowed to run off without any control.

4.2.3 Release of salts (Cl, Br, F) and dissolved organic carbon (DOC)

The leaching of Cl, Cr, F and DOC from the three test containers is tabulated in Appendix 2.3 together with the results of the blank tests (background) carried out for both the HDPE and the metal containers.

Chloride (Cl)

No QC for Cl are applicable to neither Scenario 1A nor Scenario 1B, while the LV for Cl applicable to Scenario 2 is 1000 µg/l.

As shown in Figure 4.12 and Table 4.23, the leaching of Cl from all types of WEEE was typically two orders of magnitude below the LV applicable in Scenario 2.

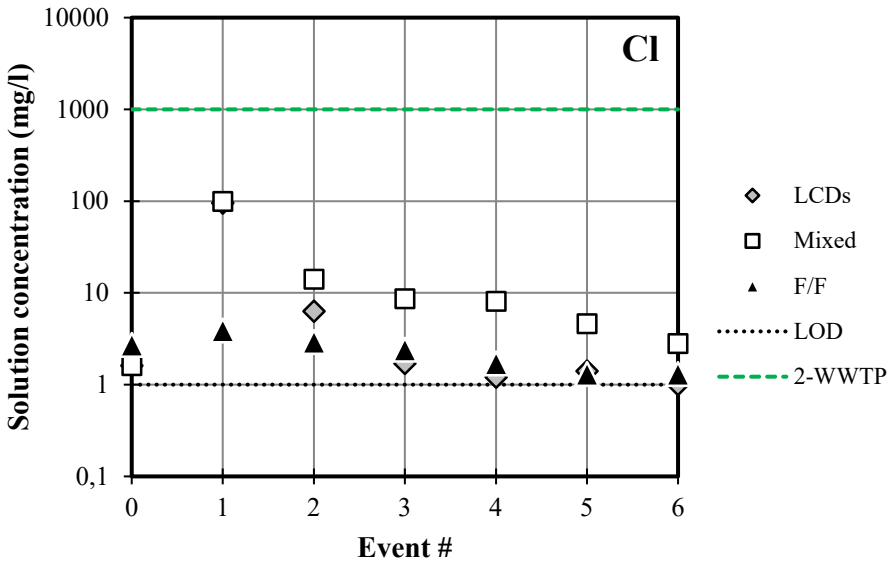


FIGURE 4.11. Solution concentrations of Cl in eluates from three different tests with WEEE compared to LV.

TABLE 4.23. Results of the 1st level assessment for Cl.

	Scenario 1A (freshwater)	Scenario 1B (marine)	Scenario 2 (sewer to WWTP)
QC; LV	-	-	1000 µg/l
Mixed WEEE	-	-	passed
LCD/CRT	-	-	passed
F/F	-	-	passed

Based on this, the leaching of **Cl** from the three types of WEEE tested in this project is assessed as **non-problematic** in relation to the outdoor storage scenarios considered.

Bromide (Br)

The leaching of Br was found to be below the LOD of 1 µg/l and is neither shown graphically nor discussed further in this section.

The leaching of **Br** from the three types of WEEE tested in this project is assessed as **non-problematic** in relation to the outdoor storage scenarios considered.

Fluoride (F)

There are no QC and/or LV for F applicable to any of the scenarios considered.

As shown in Figure 4.13, the leaching of F from all three tested WEEE-types was fairly low; typically below 1 mg/l.

Based on this, the leaching of **F** from the three types of WEEE tested in this project is assessed as **non-problematic** in relation to the outdoor storage scenarios considered.

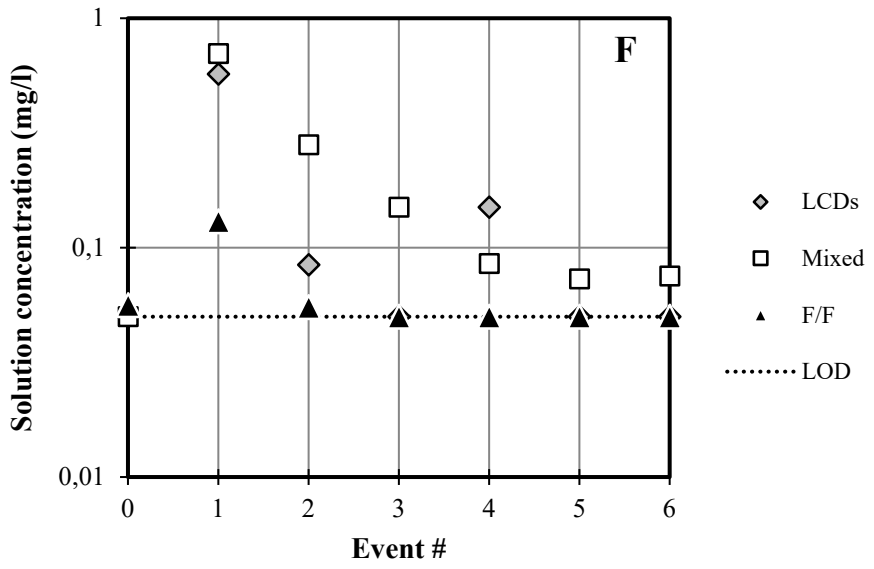


FIGURE 4.12. Concentrations of F in eluates from three different tests with WEEE.

DOC (Dissolved Organic Carbon)

There are neither QC nor LV for DOC applicable to any of the scenarios considered.

As shown in Figure 4.14, the leaching of DOC from all three tested WEEE-types was fairly low; typically below 10 mg/l. Note the increased leaching of DOC in M-6 (i.e. after the extreme irrigation event). This is believed to be caused by dust, which was flushed from the items.

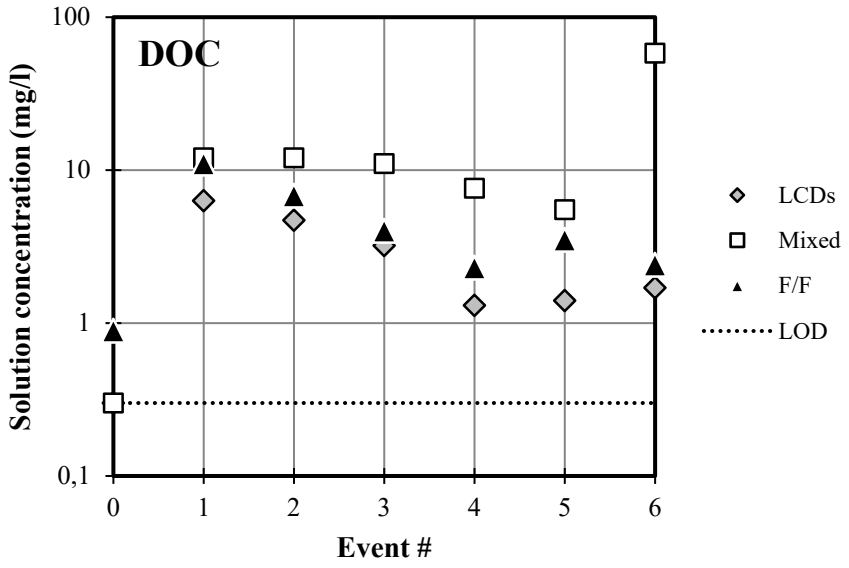


FIGURE 4.13. Concentrations of DOC in eluates from three different tests with WEEE.

Based on this, the leaching of **DOC** from the three types of WEEE tested in this project is assessed as **non-problematic** in relation to the outdoor storage scenarios considered.

4.2.4 Release of phthalates

The leaching results for phthalates are tabulated in Appendix 2.4.

The leaching of five of the seven phthalate compounds monitored in this project (i.e., dimethylphthalate (DMP), diethyl phthalate (DEP), di-n-buthylphthalate (DBP), benzylbuthylphthalate (BBP), and di-n-octylphthalate (DNOP)) was found to be below the LOD (1 µg/l for all parameters). Furthermore, since neither general QC nor LV were found for DMP, DEP and DNOP, these compounds will not be discused further.

The leaching of DBP and BBP was also found to be below the LOD 1 µg/l. However, since general QC do exist for these compounds, their leaching will be discussed.

DBP

The general QC for di-n-buthylphthalate (DBP) in Scenario 1A and Scenario 1B are 2.3 µg/l and 0.23 µg/l, respectively. There is no LV for DBP applicable to Scenario 2.

The leaching of DBP from was found to be below 1 µg/l in all eluates and the leaching from all three tested WEEE types, therefore, complied with the general QC for Scenario 1A. Unfortunately, the general QC for Scenario 1B is lower than the LOD of the analytical method used, and the leaching of DBP from all WEEE should – based on the precautionary principle – be considered as possibly problematic. Nevertheless, using the multiplication factor 10 (cf. section 3.3) would result in respectively $QC_{freshwater}$ x 10 = 23 µg/l and QC_{marine} x 10 = 2.3 µg/l (Table 3.8). As such, the leaching of DBP from all tested WEEE types would comply with the QC x 10 for both Scenario 1A and Scenario 1B.

Based on this, the leaching of **DBP** from the three types of WEEE tested in this project is assessed as **non-problematic** in relation to the outdoor storage scenarios considered.

BBP

The general QC for benzylbuthylphthalate (BBP) in Scenario 1A and Scenario 1B are 7.5 µg/l and 0.75 µg/l, respectively. There is no LV for DBP applicable to Scenario 2.

The leaching of BBP from was found to be below 1 µg/l in all eluates and the leaching from all tested WEEE types, therefore, complied with the general QC for Scenario 1A. Unfortunately, the general QC for Scenario 1B is lower than the LOD of the analytical method used, and the leaching of BBP from all WEEE should – based on the precautionary principle – be considered as possibly problematic. Nevertheless, using the multiplication factor 10 (cf. section 3.3) would result in respectively $QC_{freshwater}$ x 10 = 75 µg/l and QC_{marine} x 10 = 7.5 µg/l (Table 3.8). As such, the leaching of BBP from all tested WEEE types would comply with the QC x 10 for both Scenario 1A and Scenario 1B.

Based on this, the leaching of **BBP** from the three types of WEEE tested in this project is assessed as **non-problematic** in relation to the outdoor storage scenarios considered.

DEHA

The general QC for bis(2-ethylhexyl)adipate (DEHA) in Scenario 1A and Scenario 1B are 0.7 µg/l and 0.07 µg/l, respectively. There is no LV for DEHA applicable to Scenario 2.

As shown in Figure 4.15, the leaching of DEHA from all three tested WEEE-types was close to or below the LOD on a number of occasions, while concentrations of DEHA above LOD were detected in several eluates from L (i.e., L1, L2) and M (i.e., M2, M3), as well as in the F/F-blank. The maximum measured value in all the eluates was 4 µg/l (in M-3). Unfortunately, the general QC for Scenario 1A and Scenario 1B are significantly lower than the LOD of the analytical method used.

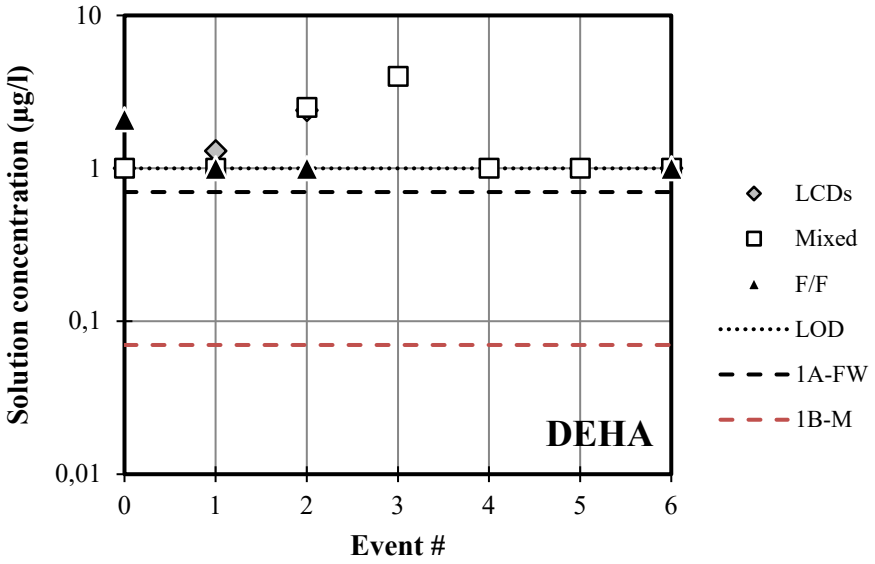


FIGURE 4.14. Concentrations of DEHA in eluates from three different tests with WEEE compared to QC.

Using the multiplication factor 10 (cf. section 3.3) would result in respectively $QC_{freshwater}$ x 10 = 7 µg/l and QC_{marine} x 10 = 0.7 µg/l (Table 3.8). As such, the leaching of DEHA from all thre WEEE types would comply with the QC x 10 for Scenario 1A while the QC x 10 for Scenario 1B would still be lower than the LOD. Hence, based on the precautionary principle, the leaching of

DEHA from all WEEE types is assessed as **possibly problematic** in relation to the outdoor storage **Scenario 1B** (direct discharge to a marine receptor). Consequently, unless proven otherwise[14], it is not recommended that any of the three tested WEEE types are exposed to percolating rainwater that is subsequently allowed to run off without any control.

DEHP

The general QC for diethylhexylphthalate (DEHP) in both Scenario 1A and Scenario 1B are 1.3 µg/l (indicated as "1A/B*" in Figure 4.16 while there is no LV for DEHP applicable to Scenario 2.

As shown in Figure 4.16, DEHP was detected in the first four eluates from M (i.e., M-1, M-2, M-3, and M-4) as well as in the first eluate from F/F. In all of the eluates, the level of DEHP was between 1.5 and 1.8 µg/l which is less than half of the concentration typically observed in drainage from artificial grass (synthetic turf)[15]. Nevertheless, the leaching of DEHP from M and F/F exceeded the general QC for Scenario 1A/1B (Table 4.24).

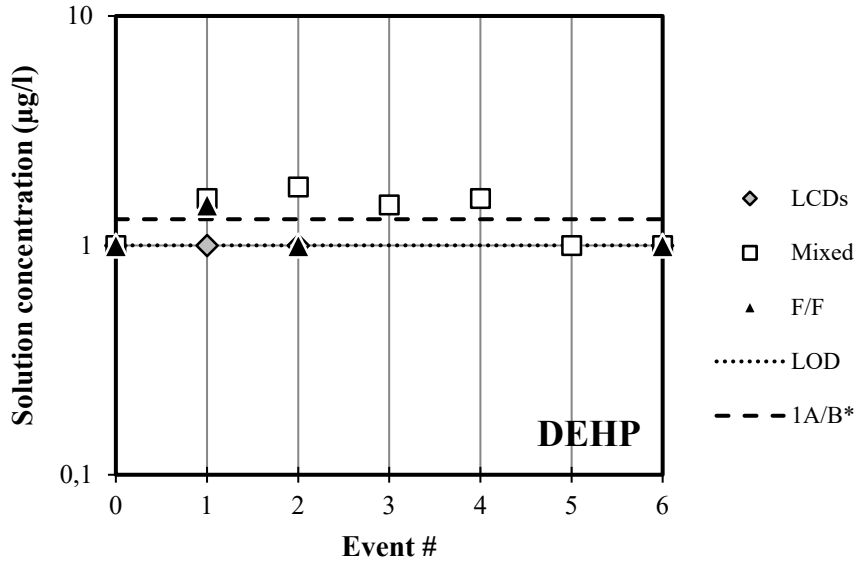


FIGURE 4.15. Solution concentrations of DEHP in eluates from three different tests with WEEE compared to QC.

TABLE 4.24. Results of the 1st level assessment for DEHP.

	Scenario 1A (freshwater)	Scenario 1B (marine)	Scenario 2 (sewer to WWTP)
QC; LV	1.3 µg/l	1.3 µg/l	-
Mixed WEEE	**exceeded**	**exceeded**	-
LCD/CRT	passed	passed	-
F/F	**exceeded**	**exceeded**	-

Using the multiplication factor 10 (cf. section 3.3) would result in $QC_{freshwater}$ x 10 = 13 µg/l; the same value applies for QC_{marine} x 10 (Table 3.8). The leaching of DEHP from all three tested WEEE types would comply with the QC x 10 for Scenario 1A and Scenario 1B (Table 4.25).

[14] e.g. a dedicated leaching test with eluate analyses with significantly lower LOD.

[15] This is discussed further in Section 4.3.

TABLE 4.25. Results of the 2nd level assessment for DEHP

	Scenario 1A (freshwater)	Scenario 1B (marine)	Scenario 2 (sewer to WWTP)
QC x 10; LV	13 µg/l	13 µg/l	-
Mixed WEEE	passed	passed	-
LCD/CRT	passed	passed	-
F/F	passed	passed	-

Based on this, the leaching of **DEHP** from the three types of WEEE tested in this project is assessed as **non-problematic** in relation to the outdoor storage scenarios considered.

4.2.5 Release of PCB

The results for leaching of PCB are tabulated in Appendix 2.5.

The solution concentrations of the seven PCB congeners measured in this project (i.e., PCB-28, PCB-52, PCB-101, PCB-118, PCB-128, PCB-153 and PCB-180 were predominantly found below the LOD of 0.001 µg/l. At a few randomly distributed occasions, slightly higher values were detected, but it should be stressed that the maximum of these was 0.0025 µg/l. This is just 2.5 times more than the LOD and thus this value is still highly uncertain as it lies around the limit of quantification (LOQ).

Based on the above-stated information, the leaching of **PCB** from the three types of WEEE tested in this project is assessed as **non-problematic** in relation to the outdoor storage scenarios considered.

4.2.6 Release of organotin compounds

The results for leaching of organotin compounds are tabulated in Appendix 2.6.

Monobutyltin (MBT) was detected in the eluates, whereas the solution concentrations of the other six organotin compounds measured in this project (i.e., tributyltin (TBT), triphenyltin (TPT), dibutyltin (DBT), monophenyltin (MPT), diphenyltin (DPT), and tricyclohexyltin (TCHT)) were found to be below the LOD of 0.02 µg/l (or 0.1 µg/l in the case of DPT).

The general QC for TBT in Scenario 1A and Scenario 1B is 0.0002 µg/l. There is no LV for TBT applicable to Scenario 2. Unfortunately, the general QC is two orders of magnitude below the LOD of the analytical method used in this project. Using the multiplication factor 10 (cf. section 3.3) would result in $QC_{freshwater}$ x 10 = 0.002 µg/l; the same value applies for QC_{marine} x 10 (Table 3.8). This is still one order of magnitude below the LOD reached in this project and, therefore, the leaching of **TBT** should – based on the precautionary principle – be considered **possibly problematic** in relation to the outdoor storage scenarios considered. Similarly, because of the relatively high LOD, the leaching of other organotin compounds (i.e. **DBT, DPT, TPT, and TCHT)** from the three types of WEEE tested in this project might be approached as **possibly problematic** during the herein considered outdoor storage scenarios.

MBT was detected in 18 of the 20 eluates collected including the blank for the M/L container which suggests a release of MBT from the plastic container in the order of 0.04 µg/l. The highest concentrations of MBT were found to be leached from M-1 (dust?), which was followed by L and finally F/F (Figure 4.17). Furthermore, both L and M showed elevated release in the last eluate (the “extreme” rain event).

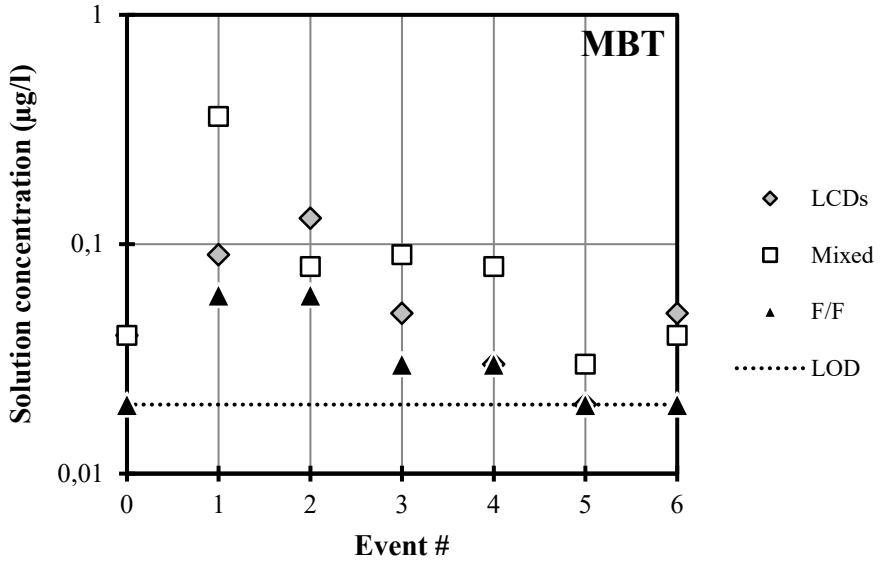


FIGURE 4.16. Solution concentrations of MBT in eluates from three different tests with WEEE compared to QC.

When the leaching trends of MBT obtained in this project are compared with those reported by Steenari and Hedberg (20013), it seems that:

- The leaching of MBT from “flat screens” reported by Steenari and Hedberg (2013) was slightly higher to comparable with the levels measured in this project for L-container (i.e. 14 LCDs + 2 CRTs); note that Steenari and Hedberg (2013) reported the leaching of MBT from only CRTs to be about 10 times higher compared with only “flat screens”.
- The leaching of MBT from “mixed WEEE” reported by Steenari and Hedberg (2013) was about 10-20 times higher than the levels measured in “mixed WEEE” used in this project.
- The leaching of MBT from “refrigerators/freezers” reported by Steenari and Hedberg (2013) was about 10 times higher than the levels measured in F/F used in this project.
- As mentioned in Table 2.2, Steenari and Hedberg (2013) speculated that older products seemed to leach more organotin compounds compared to the new products. This could be caused by either higher content of organotin in e.g. older plastics and/or by worse physical conditions of the plastic (large degree of degradation of older items would lead to the higher release of MBT).

4.2.7 Results of the screening for BFRs

The original chromatograms for all eluate samples are shown in Appendix 4.

With respect to the *targeted* screening for BFRs listed in Table 3.8, the following summary observations can be made:

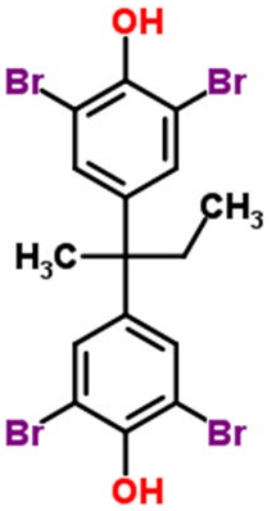
- TBBPA was found in all leachate samples (including BF and BL) but was not detected in the instrument blank (methanol containing internal standards analysed on LC-MS). In F/F samples, TBBPA levels were similar to those in BF and BL. In L samples, TBBPA was 15-70 times higher than in BF and BL, while in M samples, the peak intensities were 150-570 times those in BF and BL.
- HBCDD was occasionally detected in samples at very low signal levels (E2- low E3)
- PBDEs were detected in many samples at low signal levels (low E3), mostly tetra and penta-BDEs.
- BTBPE was found in more than 70% of samples. Low levels were found in F/F and L series samples, with higher levels found in M series samples (5x E5 signal level)

- TBP-AE was also occasionally detected (at peak intensities ranging from 1xE3 – 1xE4), mainly in M samples.
- Other compounds listed in Table 3.8 were not detected in any sample.

During the *untargeted* screening the Compound Discoverer data analysis software was configured to detect unknown compounds with a maximum chemical formula $C_{40}H_{60}Br_{15}Cl_{10}O_{10}$. Bromine patterns with up to 12 bromines were configured for pattern matching. Use of Compound Discoverer in this way revealed the presence of more than 10 unknown compounds with clear bromine/chlorine patterns. Their retention times were between 8.04 – 9.28 mins (for reference, the retention time of TBBP-A was 8.47 min and ^{13}C-BDE-28 was 9.44 min).

One of the unknown compounds (eluting at 9.28 min) was tentatively identified as $C_{16}H_{14}Br_4O_2$ (referred to as Unknown A in Table 4.26 on the next page) which could be either 4,4'-(2,2-Butanediyl)bis(2,6-dibromophenol; see Figure 4.18) a slight modification of TBBPA where one methyl group is replaced by an ethyl group, or a methoxylated derivative of TBBPA. It was found in the M3, M4 and L2 samples only. The peak intensity when detected was between 2xE6 and 1xE7, with the maximum found in the M3 sample.

FIGURE 4.17. 4,4'-(2,2-Butanediyl)bis(2,6-dibromophenol) chemical structure.



Another unknown compound eluted at 7.92 min with the chemical formula $C_6H_3Br_3O$ (referred to as Unknown A in Table 4.26). This is tentatively identified as a tribromophenol but not 2,4,6-tribromophenol (2,4,6-TBP) as this was positively identified with a retention time of 7.75 min. 2,4,6-TBP was found in every sample including BL and BF but was much more abundant in real samples. The maximum intensity was 1.5xE7 in the M3 sample and generally higher in M samples than those in samples.

Tentative chemical formulae or structures could not be assigned to the other unknown peaks detected in samples beyond the fact that they contained bromine and/or chlorine.

TABLE 4.26. Peak Intensity (red = high, green = low) of BFRs and unknown brominated compounds detected in leachate samples.

Sample	BTBPE	TBP-AE	TBBPA	HBCDD	TriBDE	TetraBDE	PentaBDE	HexaBDE	HeptaBDE	NonaBDE	Unknown A	Unknown B
M1	4.03E+04	7.71E+03	2.56E+07				1.06E+04		7.54E+03	1.72E+04	1.69E+04	5.34E+06
M2	4.29E+05	1.56E+04	6.57E+07	1.25E+03		6.84E+03	2.50E+04		2.22E+06	1.85E+04	7.47E+05	4.40E+06
M3	9.54E+04	4.51E+03	6.76E+07			6.07E+03	8.77E+03			1.32E+04	1.28E+06	1.45E+07
M4	3.98E+04	2.96E+03	5.13E+07			3.11E+03	6.11E+03			1.51E+04	3.01E+06	2.90E+06
M5	6.96E+03		9.11E+07		1.92E+03			2.03E+04		5.01E+04	9.12E+04	6.22E+04
M6	1.13E+05		2.57E+07	4.21E+04					4.67E+03		4.56E+04	4.25E+05
F1	9.89E+04		3.32E+05	4.26E+04		3.00E+03	4.64E+04				2.40E+04	1.59E+04
F2	1.17E+04		2.23E+05			5.08E+03	5.28E+04			2.72E+04	6.08E+04	5.11E+03
F3	7.65E+03		2.25E+05			9.47E+03	8.53E+04	4.54E+03			3.81E+04	3.46E+04
F4	1.11E+03		2.31E+05			6.26E+03	4.38E+04				1.66E+04	4.83E+04
F5			4.25E+04			9.95E+03	6.71E+04	1.25E+03	1.13E+03			1.76E+04
F6	1.13E+03		3.68E+04			1.10E+04	7.22E+04		3.68E+03			2.04E+04
L1	2.15E+03		1.75E+07	5.15E+03	5.78E+02	3.00E+03					7.41E+04	1.94E+05
L2	4.89E+03		1.26E+07			5.17E+03					6.71E+05	4.30E+05
L3	4.26E+03	1.48E+03	4.70E+06	5.29E+03		3.54E+03			1.32E+04		4.68E+05	4.08E+05
L4	2.78E+03	1.35E+03	4.21E+06			2.40E+03	3.78E+03		1.24E+04		6.97E+04	4.49E+05
L5			4.72E+06									2.45E+05
L6			7.87E+06	2.46E+05	4.02E+02	4.14E+03				1.12E+04	1.84E+04	1.30E+05
BF	2.38E+04		1.88E+06	1.29E+03		4.28E+03	2.10E+04		7.49E+03	2.22E+04	1.79E+04	4.35E+04
BL			2.45E+05									4.22E+04

Unknown A: $C_{16}H_{14}Br_4O_2$, Unknown B: $C_6H_3Br_3O$

4.2.8 Summary of scenario-based assessments

Results of the 1st level and the 2nd level assessment of are presented in Table 4.27.

For each element, the results are presented for all three scenarios considered: Scenario 1A (direct discharge to a freshwater receptor), Scenario 1B (direct discharge to a marine receptor) and Scenario 2 (discharge to sewer/WWTP).

TABLE 4.27. An overview of the scenario-based assessments.

Substance	WEEE-type	Scenario 1A		Scenario 1B		Scenario 2
		1st level	2nd level	1st level	2nd level	
As	M	pass	pass	pass	pass	pass
	L	pass	pass	pass	pass	pass
	F/F	fail	pass	fail	fail	fail
Ba	M	fail	pass	fail	pass	-
	L	fail	pass	fail	pass	-
	F/F	fail	pass	fail	pass	-
Cd	M	fail	pass	fail	pass	pass
	L	fail	pass	fail	pass	pass
	F/F	fail	pass	pass	-	pass
Cr	M	fail	pass	fail	pass	pass
	L	pass	-	pass	-	pass
	F/F	pass	-	pass	-	pass
Cu	M	fail	**fail**	fail	**fail**	pass
	L	fail	pass	fail	pass	pass
	F/F	fail	**fail**	fail	**fail**	**fail**
Hg	M	pass	-	pass	-	pass
	L	pass	-	pass	-	pass
	F/F	pass	-	pass	-	pass
Pb	M	fail	pass	fail	pass	pass
	L	fail	**fail**	fail	pass	pass
	F/F	fail	pass	fail	pass	pass
Ni	M	fail	pass	fail	pass	pass
	L	fail	pass	fail	pass	pass
	F/F	fail	pass	pass	-	pass
Se	M	fail by LOD	**fail by LOD**	fail by LOD	**fail by LOD**	pass
	L	fail by LOD	**fail by LOD**	fail by LOD	**fail by LOD**	pass
	F/F	fail by LOD	**fail by LOD**	fail by LOD	**fail by LOD**	pass
Sb	M	pass	-	pass	-	-
	L	pass	-	pass	-	-
	F/F	pass	-	pass	-	-
Zn	M	fail	**fail**	fail	**fail**	**fail**
	L	fail	**fail**	fail	**fail**	**fail**
	F/F	fail	**fail**	fail	**fail**	pass
Sn	M	fail	pass	fail	**fail**	pass
	L	fail	pass	fail	**fail**	pass
	F/F	pass	-	fail	pass	pass

Substance	WEEE-type	Scenario 1A		Scenario 1B		Scenario 2
		1st level	2nd level	1st level	2nd level	
Cl	M	-	-	-	-	pass
	L	-	-	-	-	pass
	F/F	-	-	-	-	pass
DBP and BBP	M	pass	-	fail by LOD	pass	-
	L	pass	-	fail by LOD	pass	-
	F/F	pass	-	fail by LOD	pass	-
DEHA	M	fail by LOD	pass	fail by LOD	**fail by LOD**	-
	L	fail by LOD	pass	fail by LOD	**fail by LOD**	-
	F/F	fail by LOD	pass	fail by LOD	**fail by LOD**	-
DEHP	M	fail	pass	fail	pass	-
	L	pass	-	pass	-	-
	F/F	fail	pass	fail	pass	-
TBT	M	fail	**fail by LOD**	fail	**fail by LOD**	-
	L	fail	**fail by LOD**	fail	**fail by LOD**	-
	F/F	fail	**fail by LOD**	fail	**fail by LOD**	-

The above mentioned results of the assessments are summarised in Table 4.28. Briefly:

- The leaching of As, Pb, and Sn from at least one type of WEEE is potentially problematic in at least one scenario.
- The leaching of Cu and Zn is potentially problematic; however, it should be noted that the observed levels were lower than the 90th percentiles measured in run-off water from Cu-plated and Zn-plated roofs, respectively. This is discussed further in section 4.3.
- The leaching of Se, DEHA and TBT may be or may not be problematic; however, the analytical methods used in this project had LOD above the QC/LV and therefore, additional information is needed in order to conclude.

TABLE 4.28. Summary of the scenario assessments.

Substance	Problematic with respect to	Note
As	F/F: Scenario 1A, Scenario 1B and Scenario 2	LOD higher than QC x 10 for Scenario 1B and Scenario 2 for F/F
Cu	M: Scenario 1A and Scenario 1B F/F: all scenarios	Used DW had a high level of Cu. Moreover, observed levels of Cu were significantly lower than the 90th percentile of Cu concentration measured in run-off water from Cu-plated roofs (cf. section 4.3).
Pb	L: Scenario 1A	-
Se	M: Scenario 1A and Scenario 1B L: Scenario 1A and Scenario 1B F/F: Scenario 1A and Scenario 1B	LOD higher than QC x 10 for Scenario 1A and Scenario 1B.
Zn	M: all scenarios L: all scenarios F/F: Scenario 1A and Scenario 1B	Observed levels of Zn were lower than the 90th percentile of Zn concentration measured in run-off water from Zn-roofs (cf. section 4.3).
Sn	M: Scenario 1B L: Scenario 1B	-
DEHA	M: Scenario 1B L: Scenario 1B	LOD higher than QC x 10 for Scenario 1B.

Substance	Problematic with respect to	Note
	F/F: Scenario 1B	
TBT	M: Scenario 1A and Scenario 1B L: Scenario 1A and Scenario 1B F/F: Scenario 1A and Scenario 1B	LOD higher than QC x 10 for Scenario 1A and Scenario 1B.

4.3 Typical composition of runoff water from different areas

In this section, the leaching from WEEE is compared with the levels of certain contaminants observed in runoff from a different type of areas.

All data used for the comparison were extracted from a "RegnKvalitet_Version1.xls" which is an Excel-based "rainwater quality-tool" (http://www.regnvandskvalitet.dk/#publikationer) that compiles data for runoff collected from different types of areas (not all will be used here), namely:

- Gardens/grass (1 dataset)
- Artificial grass/synthetic turf (up to 60 datasets for som parameters)
- Copper roofs (up to 19 datasets for some parameters)
- Zinc roofs (up to 20 datasets for some parameters)
- Other roofs (up to 19 datasets for some parameters)
- Roads with ADT[16]<5000 (up to 8 datasets for some parameters)
- Roads with ADT 5000-10000 (up to 4 datasets for some parameters)
- Roads with ADT >15000 (up to 13 datasets for some parameters)
- Parking lots for passanger vehicles (up to 6 datasets for some parameters)
- Industrial areas (up to 5 datasets for some parameters)
- Waste managements facilities such as recycling stations, shredder plants and alike (up to 11 datasets for some parameters)
- Sparingly populated residential areas (up to 4 datasets for some parameters)
- Densely populated residential areas (up to 10 datasets for some parameters)
- Other "mixed" residential areas (up to 10 datasets for some parameters)

Information about the typical levels of Zn, Cu, Pb and 4 phthalates (DBP, BBP, DEHP, DEHA) in runoff water collected from different areas are presented in Table 4.29 and Table 4.30. These parameters are selected because they are the only parameters measured in this project for which there is analytical data available in the "rainwater quality-tool".

TABLE 4.29. 90th percentile of the measured concentrations in runoff water from a selection of different areas (all data in µg/l) – PART 1

Parameter	Rainwater	Waste management facilities/shredders[17]	Industrial areas[18]	Roads (ADT[19]>15000)
Zn	7.45	3600	238	650
Cu	0.95	1100	106	164
Pb	1.08	510	15	44
DBP	0.43	12	0.10	0.21
BBP	0.071	3.6	0.10	0.13

[16] ADT<5000 refers to traffic load of less than 5000 cars per day.

[17] Data collected at several shredder plants and/or waste sorting plants in Denmark and Sweden.

[18] Data collected at Avedøre Holme (Hvidovre), Højme (Odense) and Ejby (Glostrup).

[19] ADT>15000 refers to traffic load of more than 15000 cars per day (e.g. highways).

Parameter	Rainwater	Waste management facilities/shredders[17]	Industrial areas[18]	Roads (ADT[19]>15000)
DEHP	-	47	12	12
DEHA	-	0.772	0.10	-

TABLE 4.30. 90th percentile of the measured concentrations in runoff water from a selection of different areas (all data in µg/l) – PART 2

Parameter	Artificial grass	Zinc roofs	Parking lots	Densely populated residential areas
Zn	124	8600	205	195
Cu	13	6.8	95	29
Pb	8.8	36	18	14
DBP	0.5	-	-	0.10
BBP	0.5	-	-	0.10
DEHP	4.05	-	5.9	18
DEHA	0.5	-	-	0.10

As indicated in Table 4.29 and Table 4.30, the typical level of Zn observed in runoff from populated areas, parking lots, roads as well as the artificial grass[20] is in the order of hundreds of µg/l. Runoff from waste management facilities such as recycling stations and shredder plants is in the order of few thousands µg/l. The leaching of Zn observed from the WEEE tested in this project (section 4.2.2) was comparable with the levels observed for waste management facilities such as recycling stations and shredder plants. Note that the runoff from zinc-plated roofs shows – rather expectedly – the highest concentration of Zn (Table 4.30).

The concentration of Cu in runoff from waste management facilities such as recycling stations and shredder plants appears to be the highest from the area types selected in Table 4.29 and Table 4.30, i.e. above 1000 µg/l. This is significantly above the Cu levels measured in this project; especially considering the uncertainty related to Cu measurement caused by the high content of Cu ion the DW. Nevertheless, it should be noted that the "rainwater quality-tool" shows the 90th percentile for Cu in runoff from Cu-plated roofs at 3380 µg/l (Cu-plated roofs are included in neither Table 4.29 nor Table 4.30).

The leaching of Pb observed from the WEEE tested in this project (section 4.2.2) was below the level observed for the runoff from artificial grass (Table 4.30). As such, the levels of Pb observed in eluates from herein tested WEEE were the lowest when compared with the different "surfaces" mentioned in Table 4.29 and Table 4.30.

The leaching of DPB and BBP from the WEEE tested in this project was below 1 µg/l (section 4.2.4); i.e. comparable to rainwater and/or artificial grass (Table 4.29 and Table 4.30). The leaching of DEHP from the WEEE was below 1.8 µg/l (maximum value), which is the lowest value when compared with the "surfaces" mentioned in Table 4.29 and Table 4.30. Finally, the leaching of DEHA from the WEEE was below 4 µg/l (maximum value), which is the highest value when compared with the "surfaces" mentioned in Table 4.29 and Table 4.30.

[20] Zn is present in car tyres (as ZnO), which are used in production of artificial grass.

5. Conclusions

Large scale leaching tests with three types of WEEE: “Mixed WEEE”, M, “LCDs/CRTs”, L, and “Freezers/Refrigerators (Fridges)”, F/F, were carried out in order to determine the level of potential contaminants which may be released during an outdoor storage of WEEE.

The concentration of As, Ba, Be, Cd, Cr, Cu, Hg, Pb, Ni, Se, Sb, Zn, Li, Sn, chloride, bromide, fluoride, dissolved organic carbon (DOC), organotin compounds (i.e. MBT, DBT, TBT, MPT, TPT, TCHT) was measured in all eluates. Furthermore, a qualitative screening for brominated flame retardants was carried out for all eluates. In addition, selected eluates were analysed for the content of seven PCB congeners (PCB-28, PCB-52, PCB-101, PCB-118, PCB-128, PCB-153, and PCB-180) and seven phthalates (DMP, DEP, DPB, BBP, DEHA, DEHP, and DNOP). Overall, it is concluded that:

- The contribution of the HDPE test containers to the observed leaching of metals was negligible.
- The contribution of the metal test container to the observed leaching of metals was not negligible in the case of Ba, Cd, Pb, Sn and Zn.
- The used deionised water had a high content of Cu.
- The contribution of the test containers (both HDPE- and metal-) to the observed leaching of organic compounds (phthalates, PCBs, organotin) was negligible.
- The leaching of As from F/F seems to be potentially problematic in relation to the outdoor storage Scenario 1B (discharge to a marine receptor) and Scenario 2 (discharge to a sewer/WWTP). Additional (more detailed) tests might be considered to look closer at the release of As from different parts of F/F items in order to confirm (or reject) the apparent trends observed.
- The leaching of Ba, Cd, Cr, Hg, Ni, Sb, and Li from all the tested WEEE types is assessed as non-problematic with respect to all the outdoor storage scenarios considered.
- The leaching of Pb from L is assessed as potentially problematic in relation to Scenario 1A (discharge to a freshwater receptor).
- The leaching of Se from all the tested WEEE types is assessed as possibly problematic (because of high LOD) in relation to all the outdoor storage scenarios considered. Additional tests followed by analysis with low LOD might be considered.
- The leaching of Zn from all the tested WEEE types is assessed as potentially problematic in relation to all the outdoor storage scenarios considered. However, it should be noted that the observed levels were significantly lower than the 90th percentile of Zn concentrations measured in run-off water from Zn-roofs.
- The leaching of Sn from M and L is assessed as potentially problematic in Scenario 1B (discharge to a marine receptor).
- The leaching of DOC, chloride, fluoride and bromide is assessed as non-problematic with respect to all the outdoor storage scenarios considered.
- The leaching of DMP, DEP, DPB, BBP, DEHP, and DNOP from all the tested WEEE types is assessed as non-problematic in all the outdoor storage scenarios considered.
- The leaching of DEHA from all the tested WEEE types is assessed as possibly problematic (because of high LOD) in relation to Scenario 1B (discharge to a marine receptor). Additional tests followed by analysis with low LOD might be considered.
- The leaching of PCB from all the tested WEEE types is assessed as non-problematic with respect to all the outdoor storage scenarios considered.

- The leaching of TBT (and other organotin compounds) from all the tested WEEE types is assessed as possibly problematic (because of high LOD) with respect to all the outdoor storage scenarios considered. Additional tests followed by analysis with low LOD might be considered.
- TBBPA was detected in all leachate sample (including BF and BL). The lowest levels were detected in blanks and leachates from F/F. In L samples, the levels were about 15-70 times higher while in the M samples the peak intensities were about 150-570 times higher than in BF and BL. PBDEs were detected in many samples at low signal levels, mostly tetra and penta-BDEs. BTBPE was found in more than 70% of samples. Low levels were found in F/F and L series samples, with higher levels found in M series samples. HBCDD and TBP-AE were occasionally detected as well.
- More than 10 unknown compounds (retention times were between 8.04 – 9.28 mins) with clear bromine/chlorine patterns were detected in the leachates using the data analysis software configured to detect unknown compounds with a maximum chemical formula $C_{40}H_{60}Br_{15}Cl_{10}O_{10}$. Two of the unknown compounds were tentatively identified as $C_{16}H_{14}Br_4O_2$ (which could be either 4,4'-(2,2-Butanediyl)bis(2,6-dibromophenol) or a methoxylated derivative of TBBPA) and $C_6H_3Br_3O$ (tribromophenol), respectively.

For the results of the additional tests carried out in 2022 with the focus on the release of PFAS refer to Appendix 5.

6. Literature

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Appendix 1. The WEEE used

Appendix 1.1 Overview of different WEEE-items used in the three leaching tests

TABLE 6.1. List of WEEE items used in the leaching test

	Leaching test		
Item description	**"Mixed-WEEE"**	**"LCD/CRT"**	**"Refrigerator/Freezer"**
Computer	2	-	-
Water boiling kettle	4	-	-
Rice cooker	1	-	-
Iron	3	-	-
Blender	2	-	-
Printer/scanner	3	-	-
Vacuum cleaner	1	-	-
VCR/DVD player	3	-	-
Computer keyboard	3	-	-
Computer mouse	1		
Calculator	1	-	-
Notebook/laptop	2	-	-
Microwave oven	1	-	-
Fax/telephone	4	-	-
Coffee machine	1	-	-
Toaster	1	-	-
APC Battery backup	1	-	-
Home foot spa machine	1	-	-
Bathroom scale	1	-	-
Modem	1	-	-
Cell phone	1	-	-
LCD screen	-	14	-
CRT screen	-	2	-
Refrigerator (only)	-	-	3
Refrigerator + freezer	-	-	3
Items, total count	**38**	**16**	**6**
Weight, net (kg)	**119**	**98**	**285**

TABLE 6.2. Details of items used in F/F test

Item	H x W x D (m)	A (m^2)	Brand	Type	Cooling medium[21]
1	1.43 x 0.55 x 0.55	0.30	Matsui	combined	Cycloisopentane
2	1.39 x 0.55 x 0.55	0.30	Ignis	combined	Cycloisopentane
3	1.20 x 0.55 x 0.58	0.32	Gram	refrigerator	-
4	0.88 x 0.60 x 0.55	0.33	Zanussi	refrigerator	Tetrafluorethane
5	1.45 x 0.55 x 0.52	0.29	Gorenje	combined	Pentane
6	1.08 x 0.58 x 0.56	0.33	Atlas	refrigerator	Tetrafluorethane

[21] Information obtained directly from the compressor unit

Appendix 1.2 Examples of the different WEEE-items used in the leaching tests

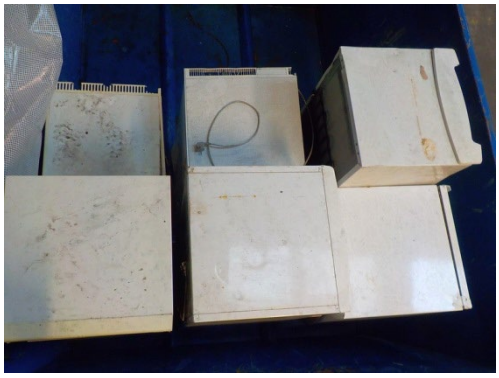
FIGURE 6.1. WEEE items included in “Mixed WEEE” (M) – part 1/2

FIGURE 6.2. WEEE items included in “Mixed WEEE” (M) – part 2/2

FIGURE 6.3. Examples of WEEE items included in “LCD/CRT” (L)

FIGURE 6.4. Examples of WEEE items included in “Refrigerator/Freezer” (F/F)

F/F test container



F/F test container (from above)

Detail of F/F items

F/F test container covered with dust cover

Appendix 2. Leaching data

Appendix 2.1 Overview of analysed samples

TABLE 6.3. Summary of the different analytical packages determined in eluates from the three leaching tests

Parameters measured in "mixed WEEE"	**#1**	**#2**	**#3**	**#4**	**#5**	**#6**
Metals + metalloids	x	x	x	x	x	x
Salts + DOC	x	x	x	x	x	x
Phthalates	x	x	x	x	x	x
Organotin	x	x	x	x	x	x
PCB	x	x		x		x
NBFR	x	x	x	x	x	x
Parameters measured in "LCDs/CRTs"	**#1**	**#2**	**#3**	**#4**	**#5**	**#6**
Metals + metalloids	x	x	x	x	x	x
Salts + DOC	x	x	x	x	x	x
Phthalates	x	x				x
Organotin	x	x	x	x	x	x
PCB	x	x		x		x
NBFR	x	x	x	x	x	x
Parameters measured in "F/F"	**#1**	**#2**	**#3**	**#4**	**#5**	**#6**
Metals + metalloids	x	x	x	x	x	x
Salts + DOC	x	x	x	x	x	x
Phthalates	x	x				x
Organotin	x	x	x	x	x	x
PCB	x	x		x		x
NBFR	x	x	x	x	x	x

Appendix 2.2 Results of the leaching tests: Metals and metalloids

TABLE 6.4. Solution concentrations measured in eluates from LCD/CRT

Parameter	Blank-L	L-1	L-2	L-3	L-4	L-5	L-6
pH	7.1	8.2	7.3	7.2	7.2	7.3	7.4
conductivity, mS/m	2.53	97.8	7.88	3.77	2.78	2.61	2.29
As, µg/l	*<0.2*	0.22	*<0.2*	*<0.2*	*<0.2*	*<0.2*	*<0.2*
Ba, µg/l	*<10*	41	16	15	10	10	15
Be, µg/l	*<0.5*	*<0.5*	*<0.5*	*<0.5*	*<0.5*	*<0.5*	*<0.5*
Cd, µg/l	*<0.03*	0.5	0.092	0.064	0.04	<0.03	0.036
Cr, µg/l	*<0.3*	1.4	0.74	0.38	0.3	0.3	0.45
Cu, µg/l	51	21	45	42	36	40	40
Hg, µg/l	*<0.03*	*<0.03*	*<0.03*	*<0.03*	*<0.03*	0.049	*<0.03*
Pb, µg/l	2.3	13	6.9	3.5	2.8	2.6	5.6
Ni, µg/l	0.5	13	8.8	7.1	6	6.3	9.1
Se, µg/l	*<2*	*<2*	*<2*	*<2*	*<2*	*<2*	*<2*
Sb, µg/l	*<0.2*	2.5	3	2.1	0.83	0.63	1.4
Zn, µg/l	190	2400	2300	2200	1500	1200	3400
Li, µg/l	10	28	6.8	*<5*	*<5*	*<5*	5.7
Sn, µg/l	*<0.1*	2.5	4.6	1.6	0.73	0.41	3.6

TABLE 6.5. Solution concentrations measured in eluates from mixed small WEEE

Parameter	M-1	M-2	M-3	M-4	M-5	M-6
pH	7.9	7.5	7.8	7.8	8.8	9.0
conductivity, mS/m	99.4	17.6	13.2	12.7	10.2	7.12
As, µg/l	0.28	*<0.2*	*<0.2*	*<0.2*	*<0.2*	*<0.2*
Ba, µg/l	48	19	23	19	16	17
Be, µg/l	*<0.5*	*<0.5*	*<0.5*	*<0.5*	*<0.5*	*<0.5*
Cd, µg/l	0.71	0.19	0.12	0.071	0.034	0.051
Cr, µg/l	9.8	3.7	1.9	1.8	0.52	0.51
Cu, µg/l	38	67	71	67	37	76
Hg, µg/l	*<0.03*	*<0.03*	*<0.03*	*<0.03*	*<0.03*	*<0.03*
Pb, µg/l	10	4.4	3.6	4.2	1.6	5.4
Ni, µg/l	26	17	14	12	7.8	9
Se, µg/l	*<2*	*<2*	*<2*	*<2*	*<2*	*<2*
Sb, µg/l	4.7	7.5	7	4.3	6.9	3.9
Zn, µg/l	6300	3000	2800	2500	2300	3900
Li, µg/l	24	11	8.1	6.4	5.2	9
Sn, µg/l	11	6.8	6.9	5.5	2.7	1.4

TABLE 6.6. Solution concentrations measured in eluates from Fridges/freezers

Parameter	Blank-F/F	F/F-1	F/F-2	F/F-3	F/F-4	F/F-5	F/F-6
pH	7.3	6.7	7.0	7.2	7.2	6.9	7.2
conductivity, mS/m	4.55	7.35	4.84	3.73	3.29	3.37	2.32
As, µg/l	0.46	36	33	20	7	2.7	1.8
Ba, µg/l	65	51	34	25	31	30	22
Be, µg/l	*<0.5*	*<0.5*	*<0.5*	*<0.5*	*<0.5*	*<0.5*	*<0.5*
Cd, µg/l	0.12	0.17	0.11	0.047	*<0.03*	0.049	0.037
Cr, µg/l	0.5	2.1	0.96	0.74	*<0.3*	*<0.3*	0.3
Cu, µg/l	42	120	99	61	53	66	76
Hg, µg/l	*<0.03*	*<0.03*	*<0.03*	*<0.03*	*<0.03*	*<0.03*	*<0.03*
Pb, µg/l	6.3	5.2	3.6	2.5	2.4	2.6	2.8
Ni, µg/l	1.1	4.5	2.4	1.3	1.1	1	0.68
Se, µg/l	*<2*	*<2*	*<2*	*<2*	*<2*	*<2*	*<2*
Sb, µg/l	0.8	1.6	0.92	0.47	0.24	0.66	0.26
Zn, µg/l	120	680	600	280	320	310	290
Li, µg/l	*<5*	*<5*	*<5*	*<5*	*<5*	*<5*	*<5*
Sn, µg/l	0.8	0.87	0.77	0.47	0.25	0.23	0.22

Appendix 2.3 Results of the leaching tests: Salts and DOC

TABLE 6.7. Solution concentrations measured in eluates from LCD/CRT

Parameter	Blank-L	L-1	L-2	L-3	L-4	L-5	L-6
Cl, mg/l	1.6	95	6.3	1.7	1.2	1.4	*<1*
Br, mg/l	*<1*	*<1*	*<1*	*<1*	*<1*	*<1*	*<1*
F, mg/l	*<0.05*	0.57	0.084	*<0.05*	0.15	*<0.05*	*<0.05*
DOC, mg/l	*<0.3*	6.3	4.7	3.2	1.3	1.4	1.7

TABLE 6.8. Solution concentrations measured in eluates from mixed WEEE

Parameter	M-1	M-2	M-3	M-4	M-5	M-6
Cl, mg/l	99	14	8.6	8.1	4.6	2.8
Br, mg/l	*<1*	*<1*	*<1*	*<1*	*<1*	*<1*
F, mg/l	0.7	0.28	0.15	0.085	0.073	0.075
DOC, mg/l	12	12	11	7.6	5.5	58

TABLE 6.9. Solution concentrations measured in eluates from Fridges/freezers

Parameter	Blank-F/F	F/F-1	F/F-2	F/F-3	F/F-4	F/F-5	F/F-6
Cl, mg/l	2.7	3.9	2.9	2.4	1.7	1.3	1.3
Br, mg/l	*<1*	*<1*	*<1*	*<1*	*<1*	*<1*	*<1*
F, mg/l	0.056	0.13	0.055	<0.05	<0.05	<0.05	*<0.05*
DOC, mg/l	0.89	11	6.8	4	2.3	3.5	2.4

Appendix 2.4 Results of the leaching tests: Phthalates

TABLE 6.10. Solution concentrations measured in eluates from LCD/CRT

Parameter	Blank-L	L-1	L-2	L-3	L-4	L-5	L-6
Dimethylphthalate, µg/l	*<1*	*<1*	*<1*	-	-	-	*<1*
Diethylphthalate, µg/l	*<1*	*<1*	*<1*	-	-	-	*<1*
Di-n-buthylphthalate, µg/l	*<1*	*<1*	*<1*	-	-	-	*<1*
Benzylbuthylphthalate, µg/l	*<1*	*<1*	*<1*	-	-	-	*<1*
Bis(2-ethylhexyl)adiapat, µg/l	*<1*	1.3	2.4	-	-	-	*<1*
Diethylhexylphthalate, µg/l	*<1*	*<1*	*<1*	-	-	-	*<1*
Di-n-octylphthalate, µg/l	*<1*	*<1*	*<1*	-	-	-	*<1*

TABLE 6.11. Solution concentrations measured in eluates from mixed WEEE

Parameter	M-1	M-2	M-3	M-4	M-5	M-6
Dimethylphthalate, µg/l	*<1*	*<1*	*<1*	*<1*	*<1*	*<1*
Diethylphthalate, µg/l	*<1*	*<1*	*<1*	*<1*	*<1*	*<1*
Di-n-buthylphthalate, µg/l	*<1*	*<1*	*<1*	*<1*	*<1*	*<1*
Benzylbuthylphthalate, µg/l	*<1*	*<1*	*<1*	*<1*	*<1*	*<1*
Bis(2-ethylhexyl)adiapat, µg/l	*<1*	2.5	4	*<1*	*<1*	*<1*
Diethylhexylphthalate, µg/l	1.6	1.8	1.5	1.6	*<1*	*<1*
Di-n-octylphthalate, µg/l	*<1*	*<1*	*<1*	*<1*	*<1*	*<1*

TABLE 6.12. Solution concentrations measured in eluates from Fridges/freezers

Parameter	Blank-F/F	F/F-1	F/F-2	F/F-3	F/F-4	F/F-5	F/F-6
Dimethylphthalate, µg/l	*<1*	*<1*	*<1*	-	-	-	*<1*
Diethylphthalate, µg/l	*<1*	*<1*	*<1*	-	-	-	*<1*
Di-n-buthylphthalate, µg/l	*<1*	*<1*	*<1*	-	-	-	*<1*
Benzylbuthylphthalate, µg/l	*<1*	*<1*	*<1*	-	-	-	*<1*
Bis(2-ethylhexyl)adiapat, µg/l	2.1	*<1*	*<1*	-	-	-	*<1*
Diethylhexylphthalate, µg/l	*<1*	1.5	*<1*	-	-	-	*<1*
Di-n-octylphthalate, µg/l	*<1*	*<1*	*<1*	-	-	-	*<1*

Appendix 2.5 Results of the leaching tests: PCBs

TABLE 6.13. Solution concentrations measured in eluates from LCD/CRT

Parameter	Blank-L	L-1	L-2	L-3	L-4	L-5	L-6
PCB-28, µg/l	0.0025	*<0.001*	*<0.001*	-	*<0.001*	-	*<0.001*
PCB-52, µg/l	0.0018	*<0.001*	*<0.001*	-	*<0.001*	-	*<0.001*
PCB-101, µg/l	*<0.001*	*<0.001*	*<0.001*	-	*<0.001*	-	*<0.001*
PCB-118, µg/l	*<0.001*	*<0.001*	*<0.001*	-	*<0.001*	-	*<0.001*
PCB-138, µg/l	*<0.001*	*<0.001*	*<0.001*	-	*<0.001*	-	*<0.001*
PCB-153, µg/l	*<0.001*	*<0.001*	*<0.001*	-	*<0.001*	-	*<0.001*
PCB-180, µg/l	*<0.001*	*<0.001*	*<0.001*	-	*<0.001*	-	*<0.001*
PCB7, sum, µg/l	*<0.007*	*<0.007*	*<0.007*	-	*<0.007*	-	*<0.007*

TABLE 6.14. Solution concentrations measured in eluates from mixed WEEE

Parameter	M-1	M-2	M-3	M-4	M-5	M-6
PCB-28, µg/l	*<0.001*	*<0.001*	-	*<0.001*	-	*<0.001*
PCB-52, µg/l	*<0.001*	*<0.001*	-	*<0.001*	-	*<0.001*
PCB-101, µg/l	*<0.001*	*<0.001*	-	*<0.001*	-	*<0.001*
PCB-118, µg/l	*<0.001*	*<0.001*	-	*<0.001*	-	*<0.001*
PCB-138, µg/l	*<0.001*	0.0017	-	*<0.001*	-	*<0.001*
PCB-153, µg/l	*<0.001*	0.0022	-	*<0.001*	-	*<0.001*
PCB-180, µg/l	*<0.001*	*<0.001*	-	*<0.001*	-	*<0.001*
PCB7, sum, µg/l	*<0.007*	0.004	-	*<0.007*	-	*<0.007*

TABLE 6.15. Solution concentrations measured in eluates from Fridges/freezers

Parameter	Blank-F/F	F/F-1	F/F-2	F/F-3	F/F-4	F/F-5	F/F-6
PCB-28, µg/l	*<0.001*	*<0.001*	*<0.001*	-	*<0.001*	-	*<0.001*
PCB-52, µg/l	*<0.001*	*<0.001*	*<0.001*	-	*<0.001*	-	*<0.001*
PCB-101, µg/l	0.001	*<0.001*	*<0.001*	-	*<0.001*	-	*<0.001*
PCB-118, µg/l	*<0.001*	*<0.001*	*<0.001*	-	*<0.001*	-	*<0.001*
PCB-138, µg/l	0.0011	*<0.001*	*<0.001*	-	*<0.001*	-	*<0.001*
PCB-153, µg/l	*<0.001*	*<0.001*	*<0.001*	-	*<0.001*	-	*<0.001*
PCB-180, µg/l	*<0.001*	*<0.001*	*<0.001*	-	*<0.001*	-	*<0.001*
PCB7, sum, µg/l	*<0.007*	*<0.007*	*<0.007*	-	*<0.007*	-	*<0.007*

Appendix 2.6 Results of the leaching tests: Organotin compounds

TABLE 6.16. Solution concentrations measured in eluates from LCD/CRT

Parameter	Blank-L	L-1	L-2	L-3	L-4	L-5	L-6
Tributyltin, µg/l	*<0.02*	*<0.02*	*<0.02*	*<0.02*	*<0.02*	*<0.02*	*<0.02*
Triphenyltin, µg/l	*<0.02*	*<0.02*	*<0.02*	*<0.02*	*<0.02*	*<0.02*	*<0.02*
Monobutyltin, µg/l	0.04	0.09	0.13	0.05	0.03	0.02	0.05
Dibutyltin, µg/l	*<0.02*	*<0.02*	*<0.02*	*<0.02*	*<0.02*	*<0.02*	0.07
Monophenyltin, µg/l	*<0.02*	*<0.02*	*<0.02*	*<0.02*	*<0.02*	*<0.02*	*<0.02*
Diphenyltin, µg/l	*<0.1*	*<0.1*	*<0.1*	*<0.1*	*<0.1*	*<0.1*	*<0.1*
Tricyclohexyltin, µg/l	*<0.02*	*<0.02*	*<0.02*	*<0.02*	*<0.02*	*<0.02*	*<0.02*

TABLE 6.17. Solution concentrations measured in eluates from mixed WEEE

Parameter	M-1	M-2	M-3	M-4	M-5	M-6
Tributyltin, µg/l	*<0.02*	*<0.02*	*<0.02*	*<0.02*	*<0.02*	*<0.02*
Triphenyltin, µg/l	*<0.02*	*<0.02*	*<0.02*	*<0.02*	*<0.02*	*<0.02*
Monobutyltin, µg/l	0.36	0.08	0.09	0.08	0.03	0.04
Dibutyltin, µg/l	0.21	0.07	*<0.02*	*<0.02*	*<0.02*	0.07
Monophenyltin, µg/l	*<0.02*	*<0.02*	*<0.02*	*<0.02*	*<0.02*	*<0.02*
Diphenyltin, µg/l	*<0.1*	*<0.1*	*<0.1*	*<0.1*	*<0.1*	*<0.1*
Tricyclohexyltin, µg/l	*<0.02*	*<0.02*	*<0.02*	*<0.02*	*<0.02*	*<0.02*

TABLE 6.18. Solution concentrations measured in eluates from Fridges/freezers

Parameter	Blank-F/F	F/F-1	F/F-2	F/F-3	F/F-4	F/F-5	F/F-6
Tributyltin, µg/l	*<0.02*	*<0.02*	*<0.02*	*<0.02*	*<0.02*	*<0.02*	*<0.02*
Triphenyltin, µg/l	*<0.02*	*<0.02*	*<0.02*	*<0.02*	*<0.02*	*<0.02*	*<0.02*
Monobutyltin, µg/l	*<0.02*	0.06	0.06	0.03	0.03	0.02	*<0.02*
Dibutyltin, µg/l	*<0.02*	*<0.02*	*<0.02*	*<0.02*	*<0.02*	*<0.02*	*<0.02*
Monophenyltin, µg/l	*<0.02*	*<0.02*	*<0.02*	*<0.02*	*<0.02*	*<0.02*	*<0.02*
Diphenyltin, µg/l	*<0.1*	*<0.1*	*<0.1*	*<0.1*	*<0.1*	*<0.1*	*<0.1*
Tricyclohexyltin, µg/l	*<0.02*	*<0.02*	*<0.02*	*<0.02*	*<0.02*	*<0.02*	*<0.02*

Appendix 2.7 Results of the leaching tests: BFR and NBFR

NOVEL BROMINATED FLAME RETARDANTS SCREENING IN LEACHATE SAMPLES PROVIDED BY DANISH WASTE SOLUTIONS

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Project Brief

To perform a qualitative screen using LC-orbitrap mass spectrometry for the brominated flame retardant content of 20 leachate experiment samples provided by Danish Waste Solutions.

Samples analysed

Samples analysed were F1-6, M1-6, L1-6, BF, and BL

Sample extraction and purification

To 250 mL of unfiltered sample (except for sample M6 where filtration was required), were added 20 ng internal standards (^{13}C-BDE28, ^{13}C-209, ^{13}C-BTBPE) to ensure analyte recovery. The treated samples were then ultrasonicated for 30 mins with 50 mL dichloromethane. Following this, the organic layer was separated. A further 50 mL of dichloromethane was added and the sample:dichloromethane mixture shaken on an automated shaker for 12 hours. Again, the dichloromethane layer was separated. This process was repeated with shaking against dichloromethane for a further 3 hours. The 3 dichloromethane extracts were combined, evaporated gently to 0.5 mL before loading onto a layered SPE cartridge containing 2 g Na_2SO_4, 6 g 44% acid silica, and 2 g Na_2SO_4. The SPE cartridge was eluted with 20 mL hexane, followed by a further 20 mL dichloromethane. The combined eluates were gently evaporated to incipient dryness prior to reconstitution in 100 µL methanol ready for instrumental analysis.

Sample Analysis

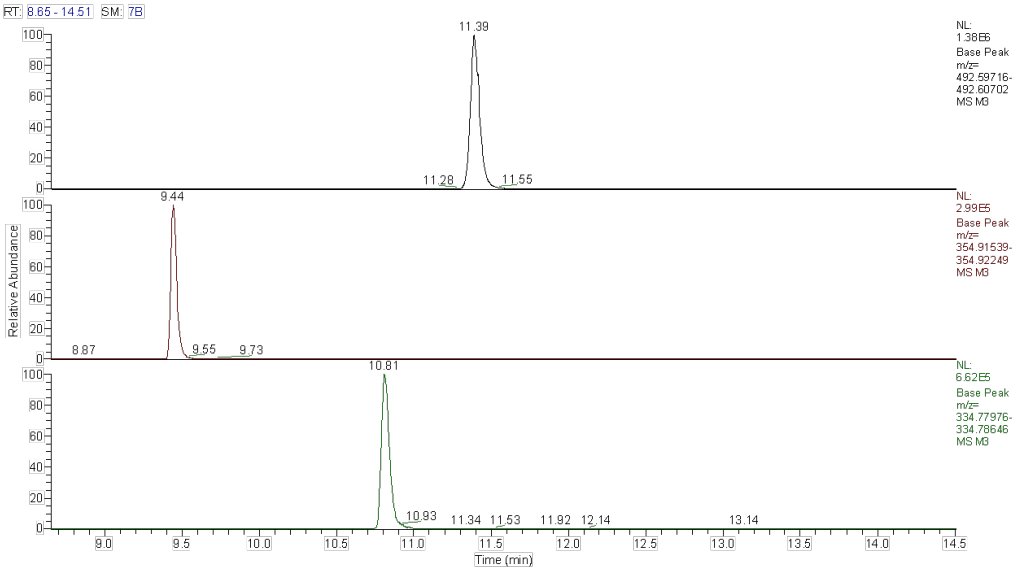
Samples were analyzed using a UPLC-Orbitrap-HRMS system (Q-Exactive, Thermo Fisher Scientific, Bremen, Germany). Chromatographic separation was performed on an Accucore RP-MS column (100 x 2.1 mm, 2.6 µm) with water (mobile phase A) and methanol (mobile phase B). A gradient method at 400 µL/min flow rate was applied as follows: start at 20% B; increase to 100% B over 9 min, held for 3 min; then decrease to 20% B over 0.1 min; and this is kept constant for a total run time of 15 min. The injection volume was 5 µL and the column oven was set at 30^{o}C.

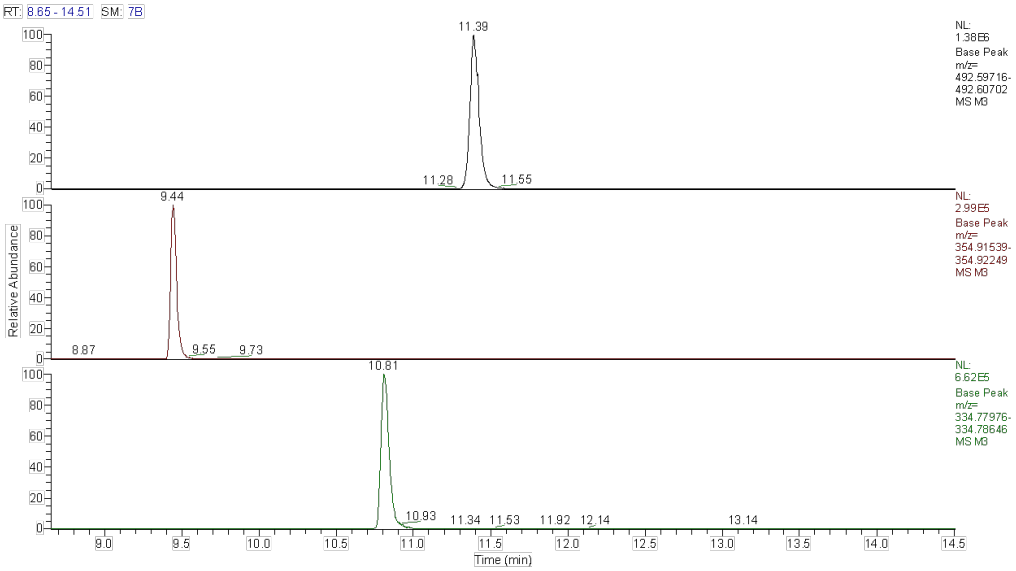
The Q-Exactive's APCI source was used to ionize samples in full scan negative ion mode. The parameters were set as follows: resolution 17500, AGC target 1 e6, maximum injection time 100 ms, scan range 300 to 1000 m/z.

Results

Figure 1 shows the extracted LC-MS chromatogram obtained for the internal standards deployed in a typical sample. This shows satisfactory transmission of these BFR standards (and by extrapolation BFRs of similar physicochemical properties) through the extraction and purification steps.

Figure 1. The extracted LC-MS chromatogram obtained for the internal standards deployed in a typical sample: ^{13}C-BDE209 (the upper most chromatogram); ^{13}C-BDE28 (the middle chromatogram); and ^{13}C-BTBPE (the bottom chromatogram).


RT: 8.65 - 14.51 SM: 7B
11.39
11.28
11.55
NL:
1.38E6
Base Peak
m/z=
492.59716-
492.60702
MS M3
9.44
8.87
9.55
9.73
NL:
2.99E5
Base Peak
m/z=
354.91539-
354.92249
MS M3
10.81
10.93
11.34
11.53
11.92
12.14
13.14
NL:
6.62E5
Base Peak
m/z=
334.77976-
334.78646
MS M3
Relative Abundance
Time (min)



Identification of Compounds

Table 1 shows those BFRs for which in-house mass spectra are available from analysis of authentic reference standards. All samples were screened for the presence of these BFRs (targeted screening), as well as for other BFRs (un-targeted screening). Those BFRs detected in each sample are listed in Table 2.

Table 1. Flame retardants in in-house mass library.

Name	Abbreviation
Polybrominated diphenyl ethers	PBDEs
Hexabromocyclododecane	HBCDD
Tetrabromobisphenol A	TBBPA
2,4,6-Tribromophenyl allyl ether	TBP-AE
2-Bromoallyl 2,4,6-tribromophenyl ether	TBP-BAE
2,3-Dibromopropyl 2,4,6-tribromophenyl ether	TBP-DBPE
Pentabromoethylbenzene	PBEB
Hexabromobenzene	HBB
Brominated biphenyl 153	BB-153
1,2-Bis(2,4,6-tribromophenoxy)ethane	BTBPE
2-Ethylhexyl 2,3,4,5-tetrabromobenzoate	EH-TBB
Bis(2-ethylhexyl) tetrabromophthalate	BEH-TEBP
5,6-Dibromo-1,10,11,12,13,13-hexachloro-11- tricyclo[8.2.1.02,9]tridecene	HCDBCO
Octabromotrimethylphenyl indane	OBTMPI
Decachloropentacyclodecan-5-one	Chlordecone
Dechlorane plus	DPs

With respect to the BFRs listed in Table 1 (targeted screening), the following summary observations can be made:

- TBBPA was found in all leachate samples (including BF and BL) but was not detected in the instrument blank (methanol containing internal standards analysed on LC-MS). In F samples, TBBPA levels were similar to those in BF and BL. In L samples, TBBPA was 15-70 times higher than in BF and BL, while in M samples, the peak intensities were 150-570 times those in BF and BL.
- HBCDD was occasionally detected in samples at very low signal levels (E2- low E3)

- PBDEs were detected in many samples at low signal levels (low E3), mostly tetra and penta-BDEs.
- BTBPE was found in more than 70 % of samples. Low levels were found in F and L series samples, with higher levels found in M series samples (5 x E5 signal level)
- TBP-AE was also occasionally detected (at peak intensities ranging from 1 x E3 – 1 x E4), mainly in M samples.
- Other compounds listed in Table 1 were no detected in any sample.

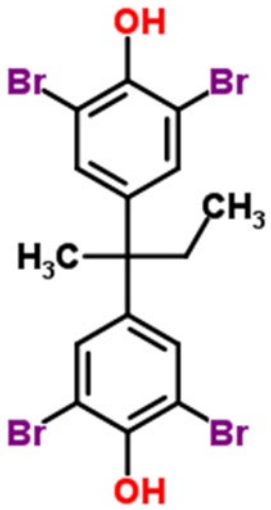
Compound Discoverer – Untargeted screening

The Compound Discoverer data analysis software was configured to detect unknown compounds with a maximum chemical formula C_{40} H_{60} Br_{15} Cl_{10} O_{10}. Bromine patterns with up to 12 bromines were configured for pattern matching.

Use of Compound Discoverer in this way revealed the presence of more than 10 unknown compounds with clear bromine/chlorine patterns. Their retention times were between 8.04 – 9.28 mins (for reference, the retention time of TBBP-A was 8.47 min and ^{13}C-BDE-28 was 9.44 min).

One of the unknown compounds (eluting at 9.28 min) was tentatively identified as $C_{16}H_{14}Br_4O_2$ which could be either 4,4'-(2,2-Butanediyl)bis(2,6-dibromophenol – see Figure 2) a slight modification of TBBPA where one methyl group is replaced by an ethyl group, or a methoxylated derivative of TBBPA. It was found in the M3, M4 and L2 samples only. The peak intensity when detected was between 2 x E6 and 1 x E7, with the maximum found in the M3 sample.

Figure 2. 4,4'-(2,2-Butanediyl)bis(2,6-dibromophenol) chemical structure.



Another unknown compound eluted at 7.92 min with the chemical formula $C_6H_3Br_3O$. This is tentatively identified as a tribromophenol but not 2,4,6-tribromophenol (2,4,6-TBP) as this was positively identified with a retention time of 7.75 min. 2,4,6-TBP was found in every sample including BL and BF but was much more abundant in real samples. The maximum intensity was 1.5 x E7 in the M3 sample and generally higher in M samples than those in samples.

Tentative chemical formulae or structures could not be assigned to the other unknown peaks detected in samples beyond the fact that they contained bromine and/or chlorine.

Table 2. Peak intensity (red = high, green = low) of brominated flame retardants and unknown brominated compounds detected in leachate samples.

Sample	BTBPE	TBP-AE	TBBPA	HBCDD	TriBDE	TetraBDE	PentaBDE	HexaBDE	HeptaBDE	NonaBDE	Unknown A	Unknown B
M1	4.03E+04	7.71E+03	2.56E+07				1.06E+04		7.54E+03	1.72E+04	1.69E+04	5.34E+06
M2	4.29E+05	1.56E+04	6.57E+07	1.25E+03		6.84E+03	2.50E+04		2.22E+06	1.85E+04	7.47E+05	4.40E+06
M3	9.54E+04	4.51E+03	6.76E+07			6.07E+03	8.77E+03			1.32E+04	1.28E+06	1.45E+07
M4	3.98E+04	2.96E+03	5.13E+07			3.11E+03	6.11E+03			1.51E+04	3.01E+06	2.90E+06
M5	6.96E+03		9.11E+07		1.92E+03			2.03E+04		5.01E+04	9.12E+04	6.22E+04
M6	1.13E+05		2.57E+07	4.21E+04					4.67E+03		4.56E+04	4.25E+05
F1	9.89E+04		3.32E+05	4.26E+04		3.00E+03	4.64E+04				2.40E+04	1.59E+04
F2	1.17E+04		2.23E+05			5.08E+03	5.28E+04			2.72E+04	6.08E+04	5.11E+03
F3	7.65E+03		2.25E+05			9.47E+03	8.53E+04	4.54E+03			3.81E+04	3.46E+04
F4	1.11E+03		2.31E+05			6.26E+03	4.38E+04				1.66E+04	4.83E+04
F5			4.25E+04			9.95E+03	6.71E+04	1.25E+03	1.13E+03			1.76E+04
F6	1.13E+03		3.68E+04			1.10E+04	7.22E+04		3.68E+03			2.04E+04
L1	2.15E+03		1.75E+07	5.15E+03	5.78E+02	3.00E+03					7.41E+04	1.94E+05
L2	4.89E+03		1.26E+07			5.17E+03					6.71E+05	4.30E+05
L3	4.26E+03	1.48E+03	4.70E+06	5.29E+03		3.54E+03			1.32E+04		4.68E+05	4.08E+05
L4	2.78E+03	1.35E+03	4.21E+06			2.40E+03	3.78E+03		1.24E+04		6.97E+04	4.49E+05
L5			4.72E+06									2.45E+05
L6			7.87E+06	2.46E+05	4.02E+02	4.14E+03				1.12E+04	1.84E+04	1.30E+05
BF	2.38E+04		1.88E+06	1.29E+03		4.28E+03	2.10E+04		7.49E+03	2.22E+04	1.79E+04	4.35E+04
BL			2.45E+05									4.22E+04

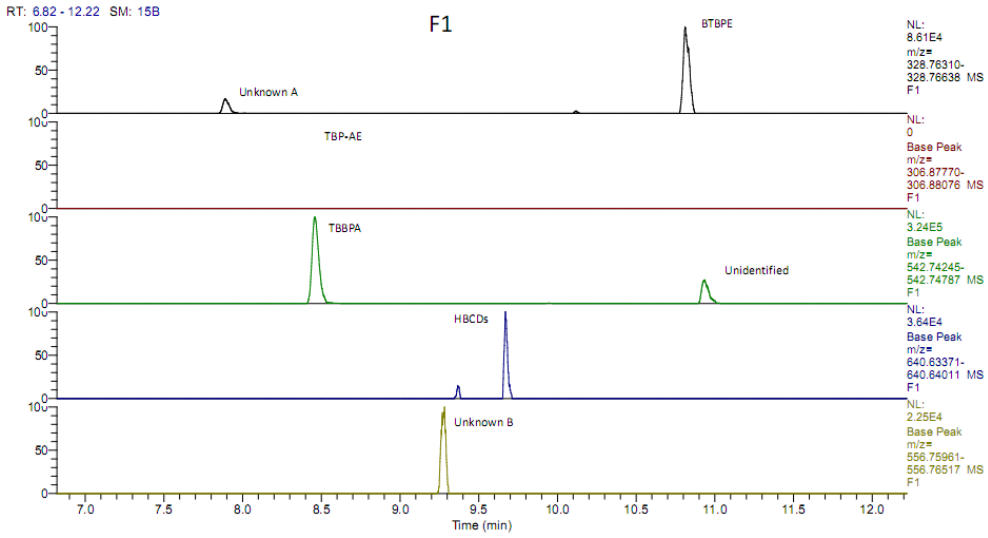
Unknown A: $C_{16}H_{14}Br_4O_2$, Unknown B: $C_6H_3Br_3O$

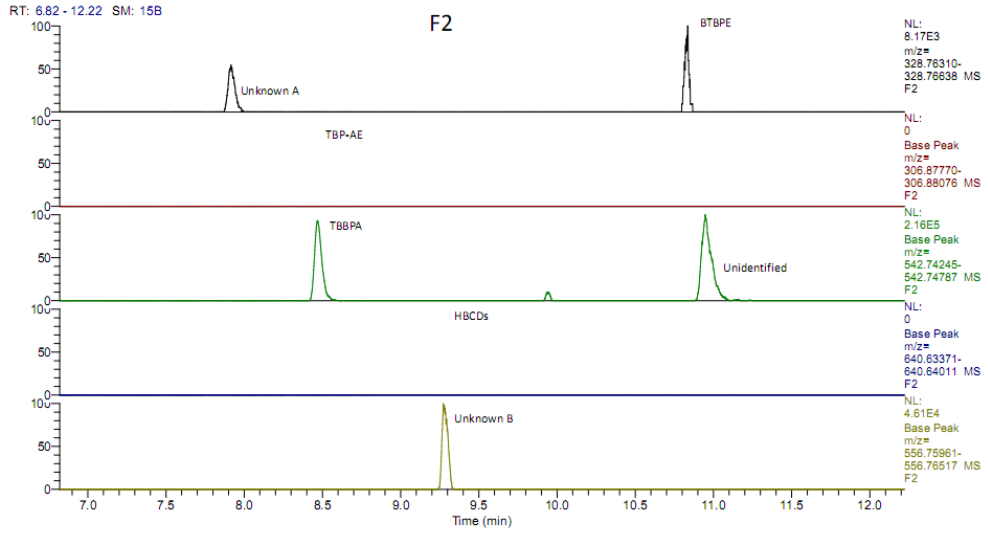
Appendix 3. Analytical reports

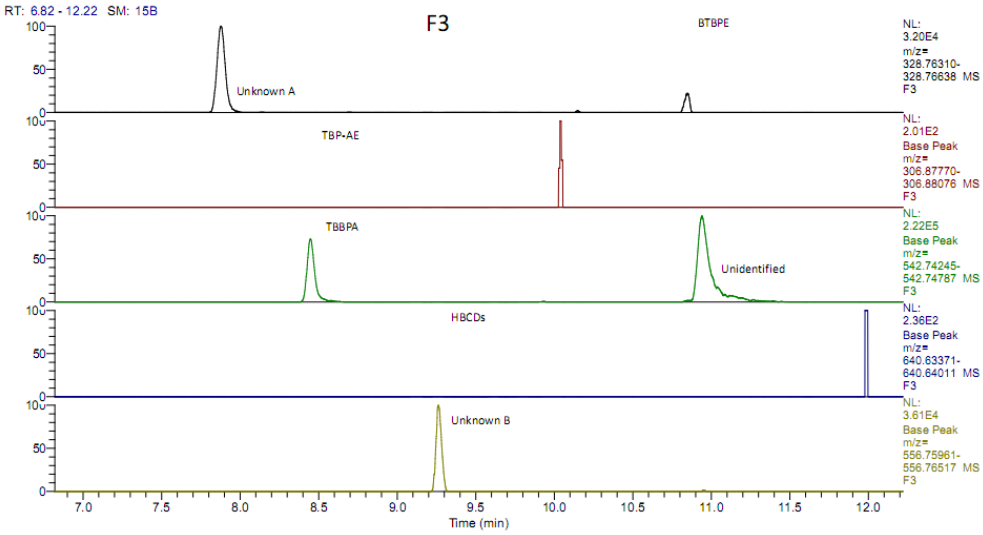
This appendix includes the original analytical data for parameters determined during the first study in 2016; i.e. metals, metalloids, salts, dissolved organic carbon, polychlorinated biphenyls, phthalates, organotin compounds and brominated flame retardants (with special focus on “novel” brominated flame retardants). For additional information refer to Section 3.2.3.

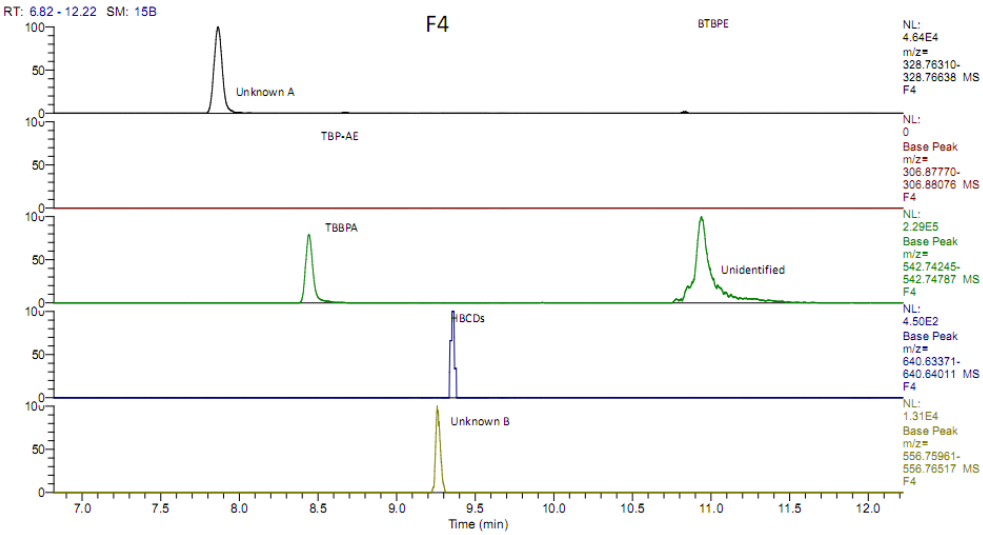
Appendix 4. Chromatograms (BFRs)

Appendix 4.1 Unknown A/B, BTBPE, TBP-AE, TBBPA, and HBCDs






RT: 6.82 - 12.22 SM: 15B
F3
BTBPE
Unknown A
TBP-AE
TBBPA
Unidentified
HBCDs
Unknown B
NL: 3.20E4 m/z= 328.76310-328.76638 MS F3
NL: 2.01E2 Base Peak m/z= 306.87770-306.88076 MS F3
NL: 2.22E5 Base Peak m/z= 542.74245-542.74787 MS F3
NL: 2.36E2 Base Peak m/z= 640.63371-640.64011 MS F3
NL: 3.61E4 Base Peak m/z= 556.75961-556.76517 MS F3
Time (min)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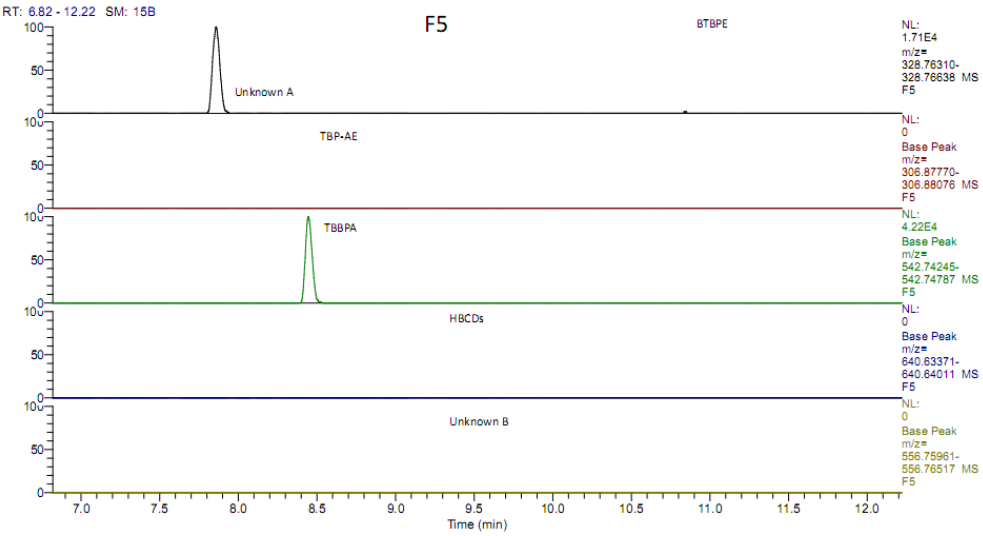
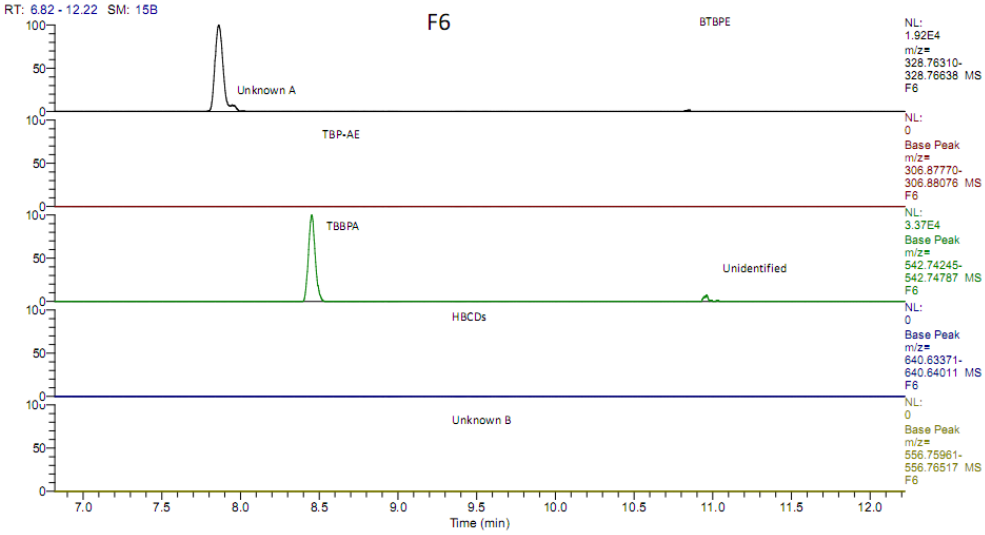
F4
BTBPE
Unknown A
TBP-AE
TBBPA
Unidentified
HBCDs
Unknown B
NL: 4.64E4 m/z= 328.76310-328.76638 MS F4
NL: 0 Base Peak m/z= 306.87770-306.88076 MS F4
NL: 2.29E5 Base Peak m/z= 542.74245-542.74787 MS F4
NL: 4.50E2 Base Peak m/z= 640.63371-640.64011 MS F4
NL: 1.31E4 Base Peak m/z= 556.75961-556.76517 MS F4
Time (min)


RT: 6.82 - 12.22 SM: 15B
F5
BTBPE
Unknown A
TBP-AE
TBBPA
HBCDs
Unknown B
NL: 1.71E4 m/z= 328.76310-328.76638 MS F5
NL: 0 Base Peak m/z= 306.87770-306.88076 MS F5
NL: 4.22E4 Base Peak m/z= 542.74245-542.74787 MS F5
NL: 0 Base Peak m/z= 640.63371-640.64011 MS F5
NL: 0 Base Peak m/z= 556.75961-556.76517 MS F5
Time (min)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Unknown A
TBP-AE
TBBPA
Unidentified
HBCDs
Unknown B
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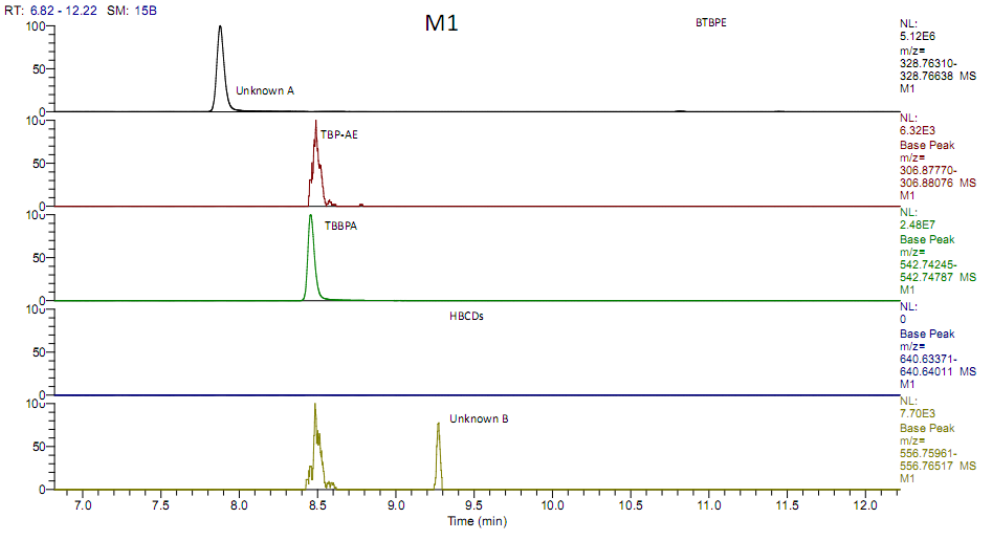
NL: 0 Base Peak m/z= 306.87770-306.88076 MS F6
NL: 3.37E4 Base Peak m/z= 542.74245-542.74787 MS F6
NL: 0 Base Peak m/z= 640.63371-640.64011 MS F6
NL: 0 Base Peak m/z= 556.75961-556.76517 MS F6
Time (min)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M1
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Unknown A
TBP-AE
TBBPA
HBCDs
Unknown B
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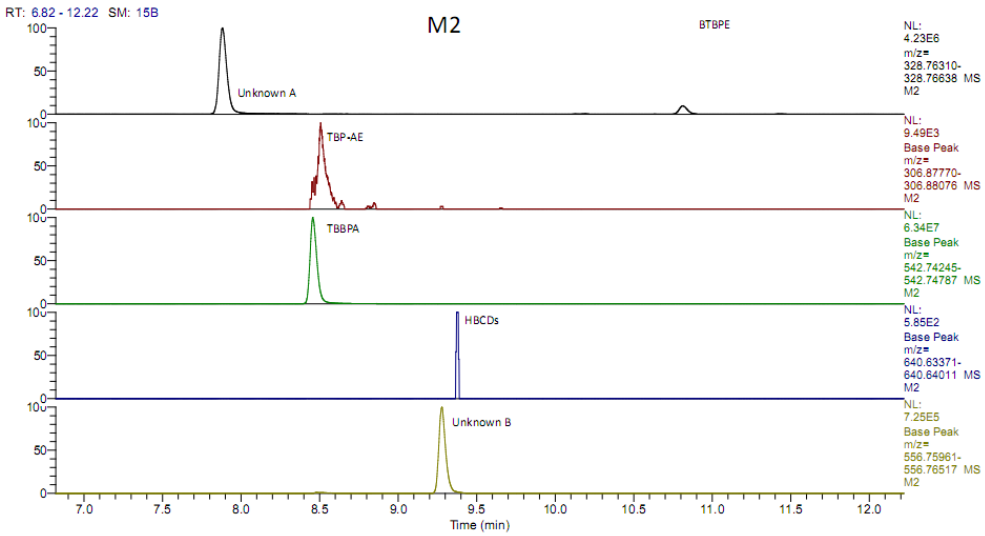
NL: 6.32E3 Base Peak m/z= 306.87770-306.88076 MS M1
NL: 2.48E7 Base Peak m/z= 542.74245-542.74787 MS M1
NL: 0 Base Peak m/z= 640.63371-640.64011 MS M1
NL: 7.70E3 Base Peak m/z= 556.75961-556.76517 MS M1
Time (min)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M2
BTBPE
Unknown A
TBP-AE
TBBPA
HBCDs
Unknown B
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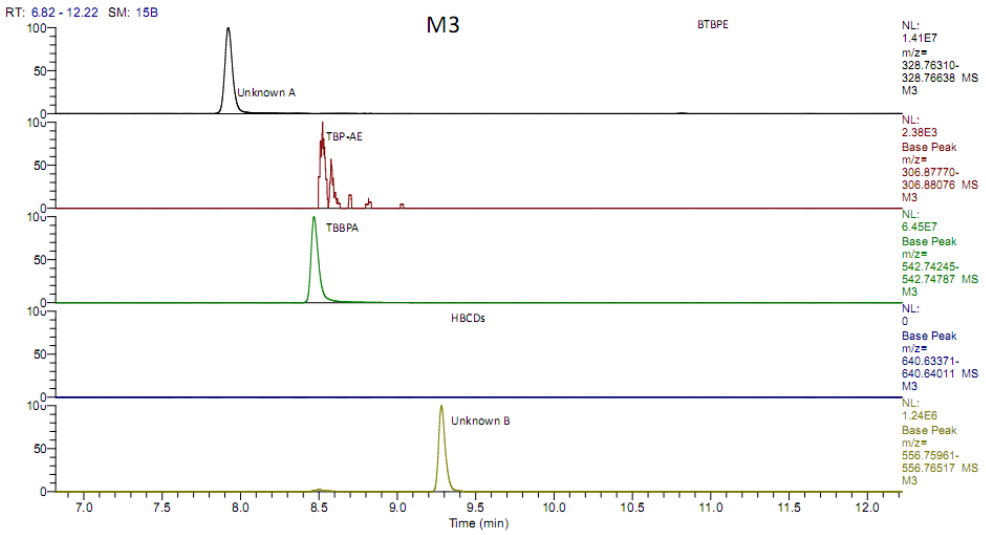
NL: 9.49E3 Base Peak m/z= 306.87770-306.88076 MS M2
NL: 6.34E7 Base Peak m/z= 542.74245-542.74787 MS M2
NL: 5.85E2 Base Peak m/z= 640.63371-640.64011 MS M2
NL: 7.25E5 Base Peak m/z= 556.75961-556.76517 MS M2
Time (min)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TBP-AE
TBBPA
HBCDs
Unknown B
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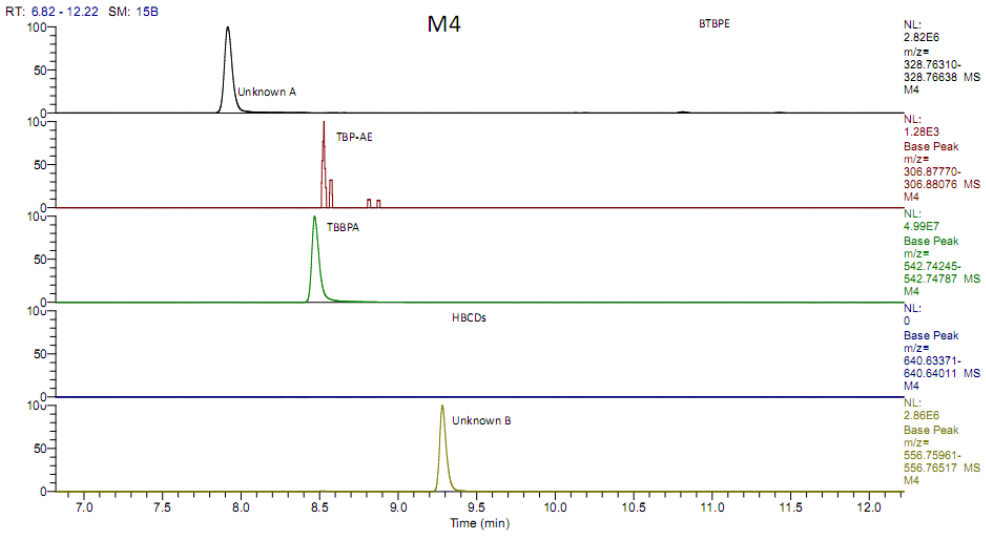
NL: 2.38E3 Base Peak m/z= 306.87770-306.88076 MS M3
NL: 6.45E7 Base Peak m/z= 542.74245-542.74787 MS M3
NL: 0 Base Peak m/z= 640.63371-640.64011 MS M3
NL: 1.24E6 Base Peak m/z= 556.75961-556.76517 MS M3
Time (min)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Unknown A
TBP-AE
TBBPA
HBCDs
Unknown B
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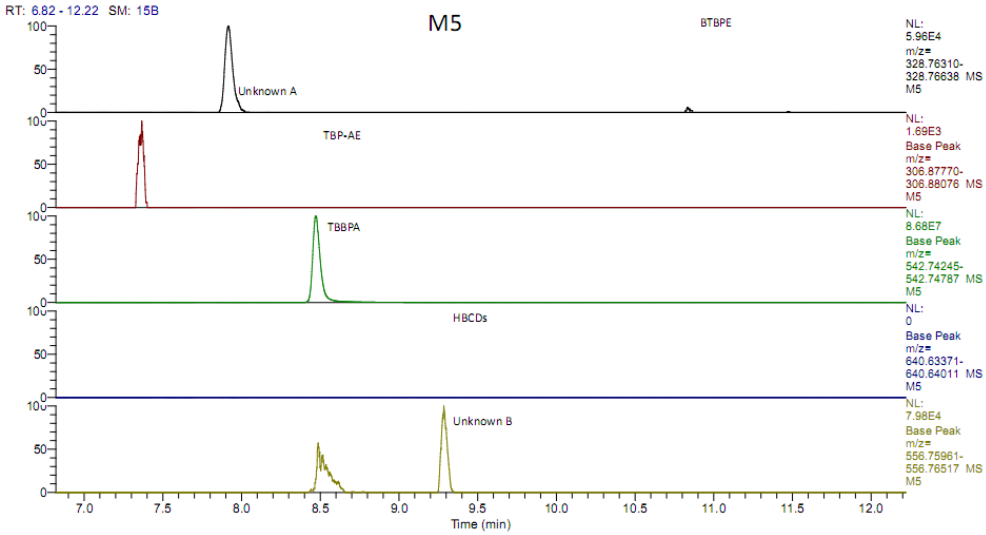
NL: 1.28E3 Base Peak m/z= 306.87770-306.88076 MS M4
NL: 4.99E7 Base Peak m/z= 542.74245-542.74787 MS M4
NL: 0 Base Peak m/z= 640.63371-640.64011 MS M4
NL: 2.86E6 Base Peak m/z= 556.75961-556.76517 MS M4
Time (min)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M5
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Unknown A
TBP-AE
TBBPA
HBCDs
Unknown B
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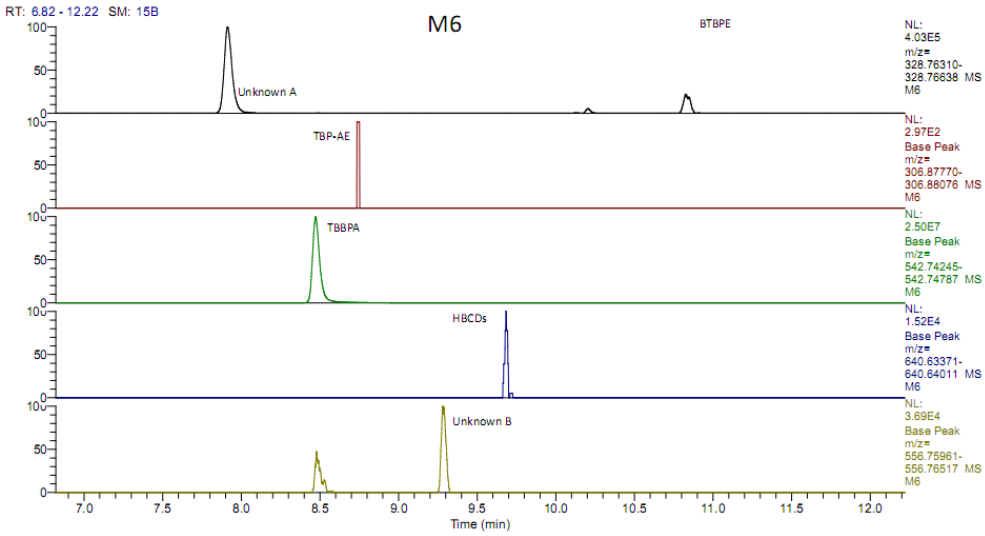
NL: 1.69E3 Base Peak m/z= 306.87770-306.88076 MS M5
NL: 8.68E7 Base Peak m/z= 542.74245-542.74787 MS M5
NL: 0 Base Peak m/z= 640.63371-640.64011 MS M5
NL: 7.98E4 Base Peak m/z= 556.75961-556.76517 MS M5
Time (min)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M6
BTBPE
Unknown A
TBP-AE
TBBPA
HBCDs
Unknown B
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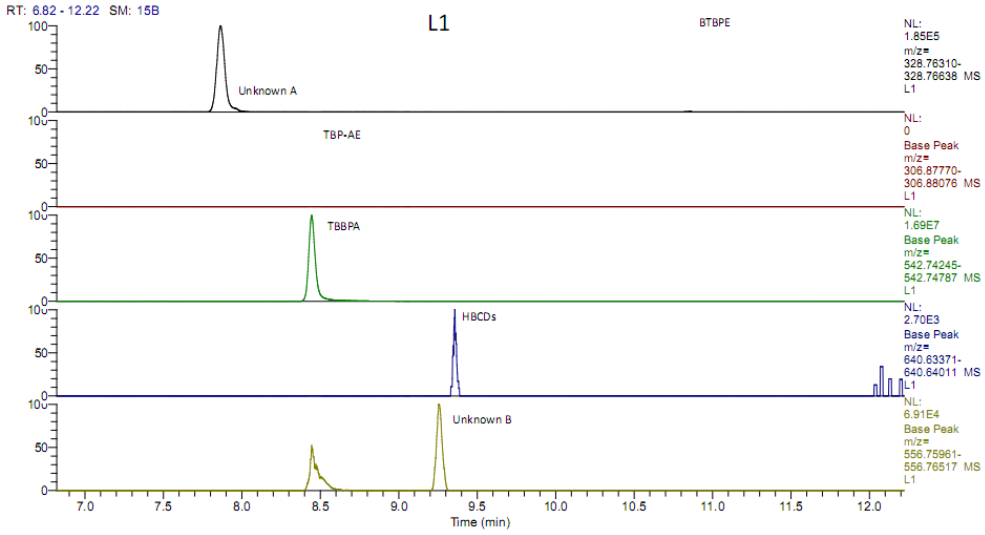
NL: 2.97E2 Base Peak m/z= 306.87770-306.88076 MS M6
NL: 2.50E7 Base Peak m/z= 542.74245-542.74787 MS M6
NL: 1.52E4 Base Peak m/z= 640.63371-640.64011 MS M6
NL: 3.69E4 Base Peak m/z= 556.75961-556.76517 MS M6
Time (min)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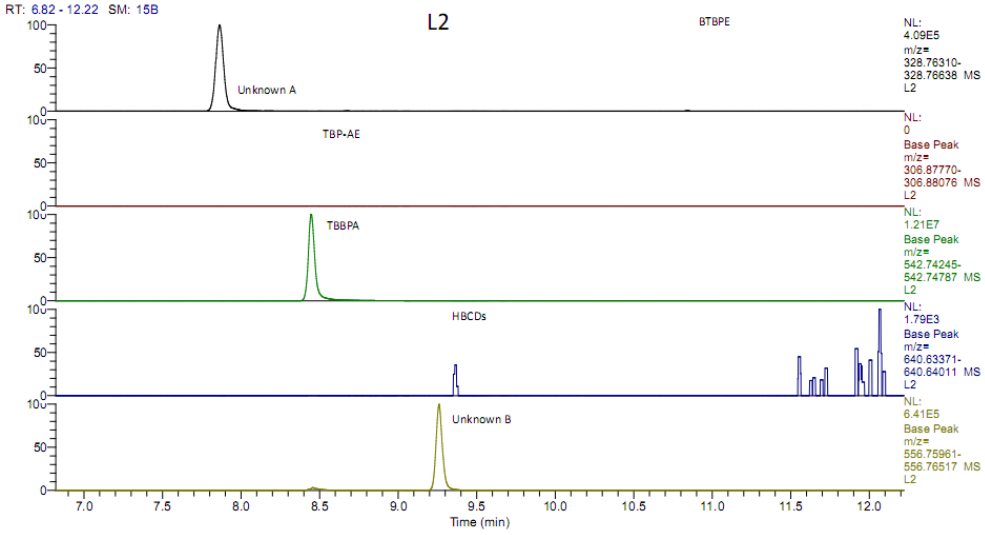
TBP-AE
TBBPA
HBCDs
Unknown B
NL: 1.85E5 m/z= 328.76310-328.76638 MS L1
NL: 0 Base Peak m/z= 306.87770-306.88076 MS L1
NL: 1.69E7 Base Peak m/z= 542.74245-542.74787 MS L1
NL: 2.70E3 Base Peak m/z= 640.63371-640.64011 MS L1
NL: 6.91E4 Base Peak m/z= 556.75961-556.76517 MS L1
Time (min)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L2
BTBPE
Unknown A
TBP-AE
TBBPA
HBCDs
Unknown B
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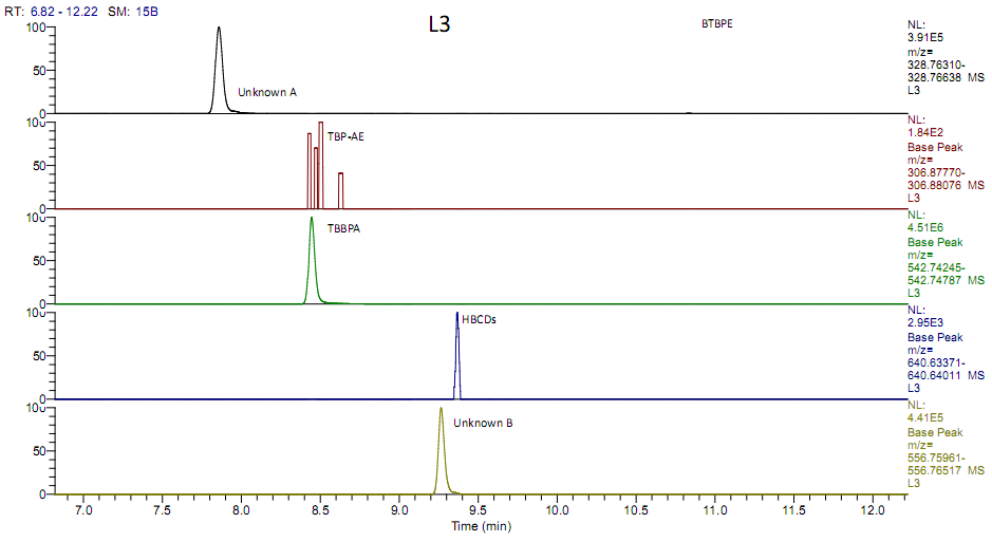
NL: 0 Base Peak m/z= 306.87770-306.88076 MS L2
NL: 1.21E7 Base Peak m/z= 542.74245-542.74787 MS L2
NL: 1.79E3 Base Peak m/z= 640.63371-640.64011 MS L2
NL: 6.41E5 Base Peak m/z= 556.75961-556.76517 MS L2
Time (min)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Unknown A
TBP-AE
TBBPA
HBCDs
Unknown B
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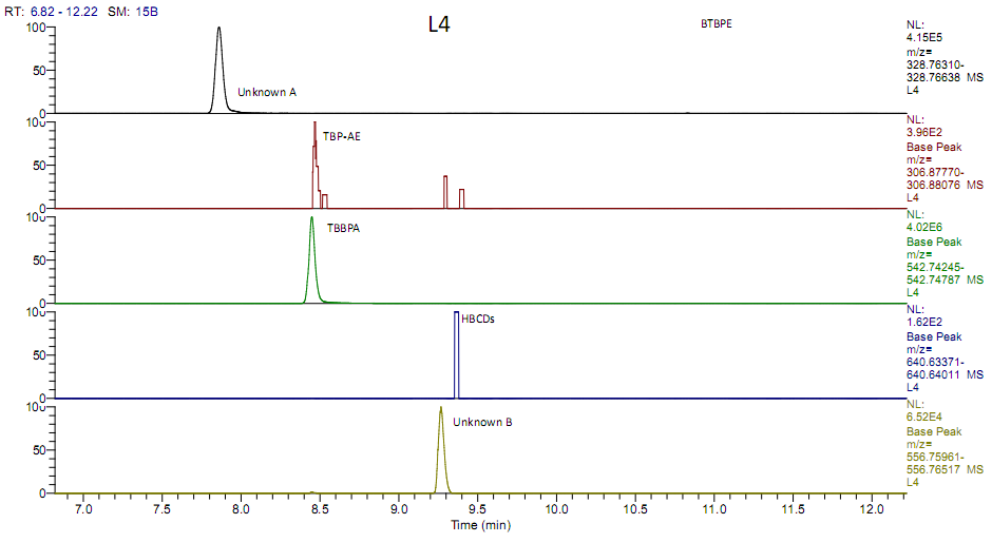
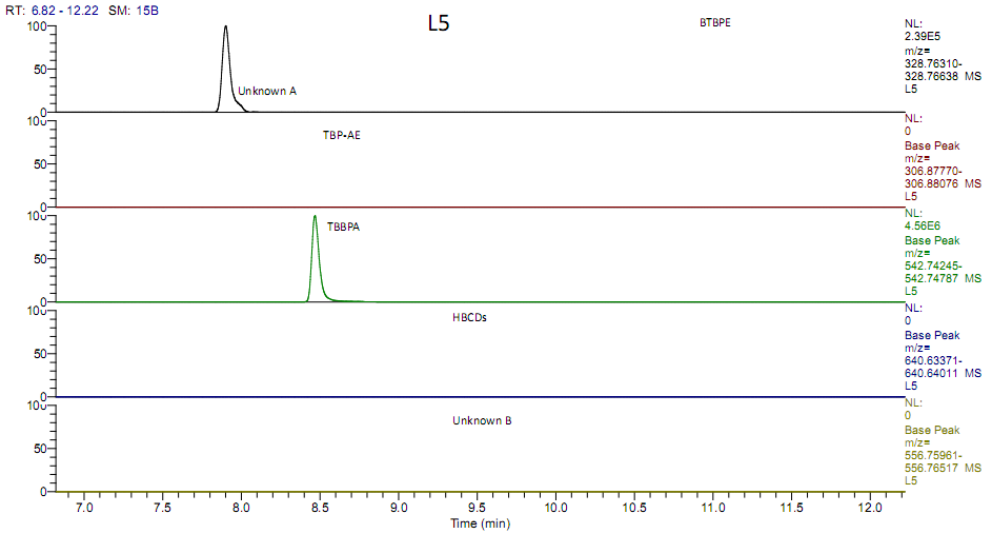
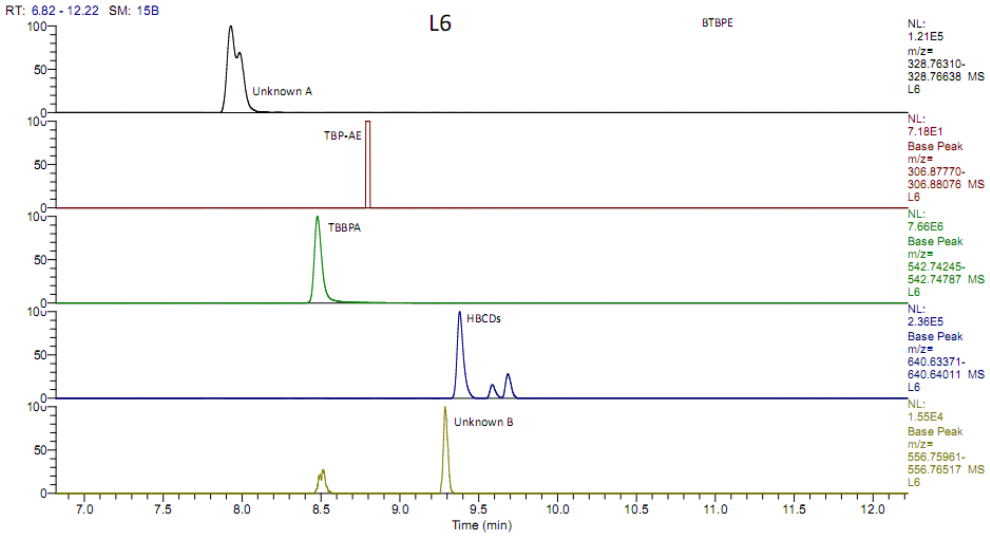
NL: 1.84E2 Base Peak m/z= 306.87770-306.88076 MS L3
NL: 4.51E6 Base Peak m/z= 542.74245-542.74787 MS L3
NL: 2.95E3 Base Peak m/z= 640.63371-640.64011 MS L3
NL: 4.41E5 Base Peak m/z= 556.75961-556.76517 MS L3
Time (min)


RT: 6.82 - 12.22 SM: 15B
L4
BTBPE
Unknown A
TBP-AE
TBBPA
HBCDs
Unknown B
NL: 4.15E5 m/z= 328.76310-328.76638 MS L4
NL: 3.96E2 Base Peak m/z= 306.87770-306.88076 MS L4
NL: 4.02E6 Base Peak m/z= 542.74245-542.74787 MS L4
NL: 1.62E2 Base Peak m/z= 640.63371-640.64011 MS L4
NL: 6.52E4 Base Peak m/z= 556.75961-556.76517 MS L4
Time (min)


RT: 6.82 - 12.22 SM: 15B
L5
BTBPE
Unknown A
TBP-AE
TBBPA
HBCDs
Unknown B
NL: 2.39E5 m/z= 328.76310-328.76638 MS L5
NL: 0 Base Peak m/z= 306.87770-306.88076 MS L5
NL: 4.56E6 Base Peak m/z= 542.74245-542.74787 MS L5
NL: 0 Base Peak m/z= 640.63371-640.64011 MS L5
NL: 0 Base Peak m/z= 556.75961-556.76517 MS L5
Time (min)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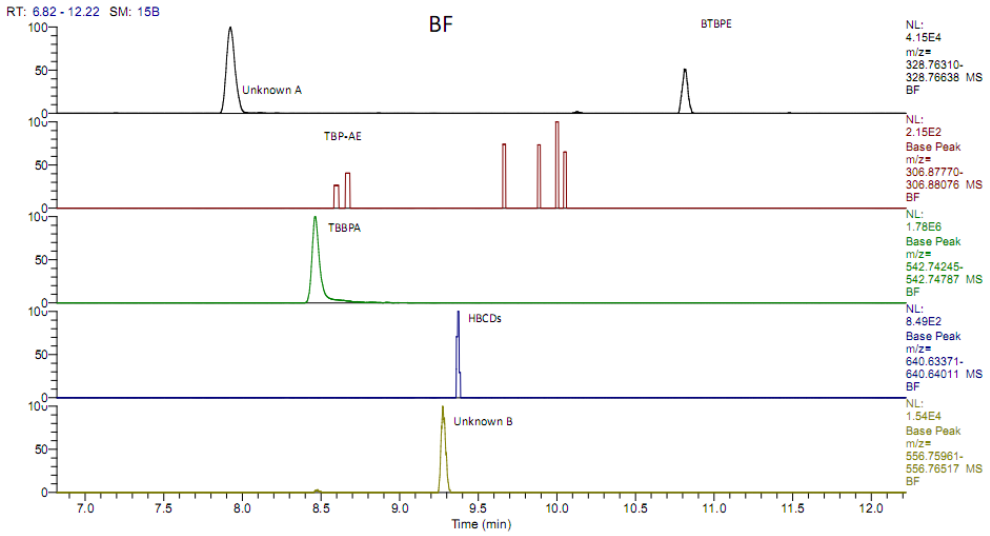
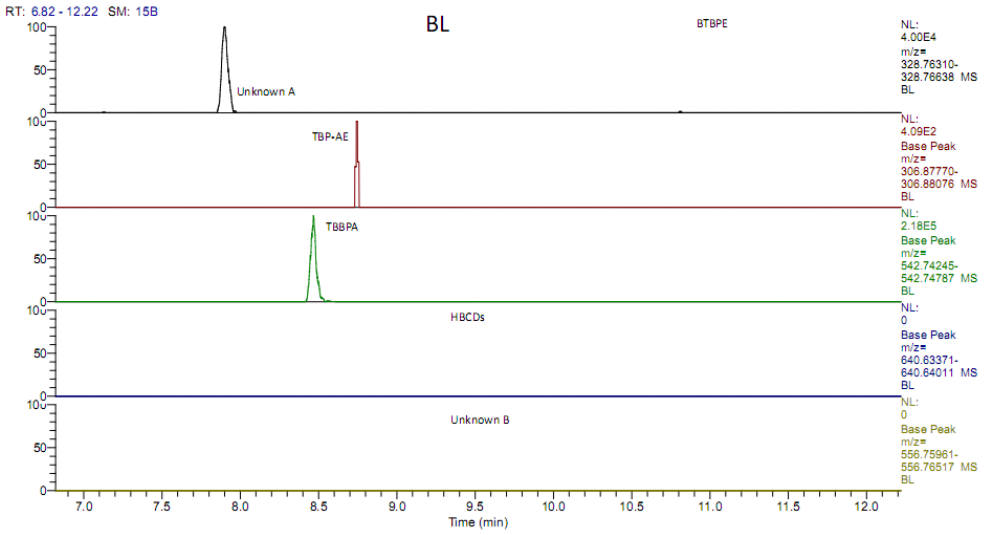
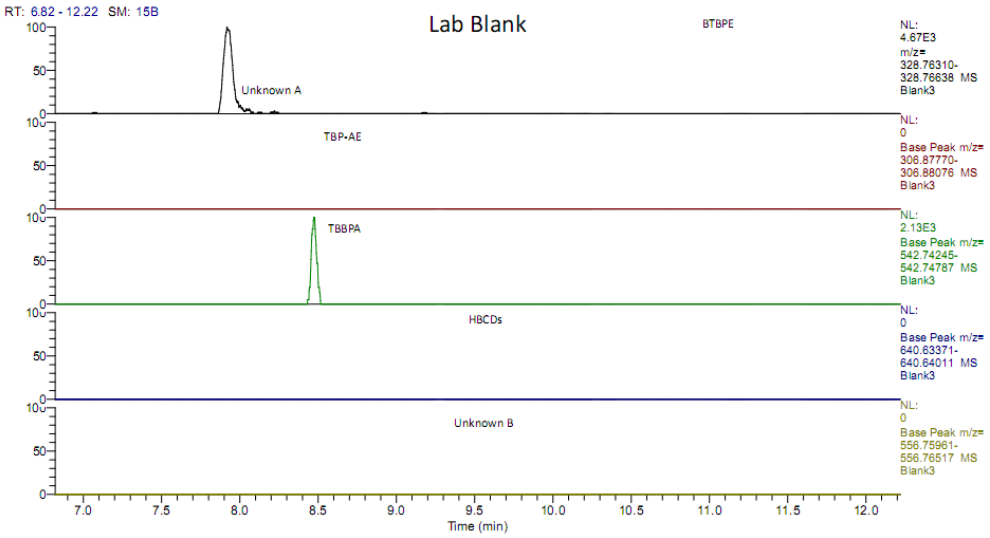
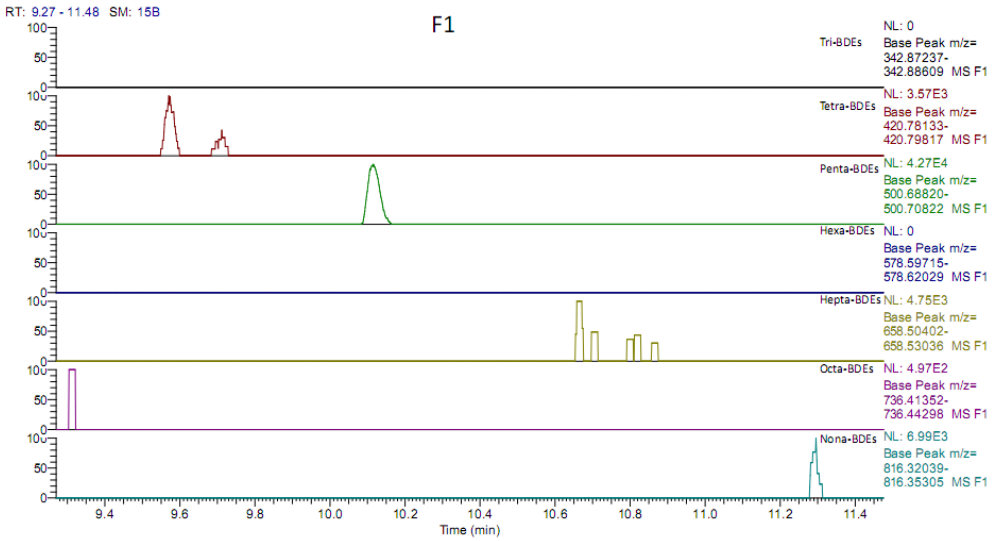
L6
BTBPE
Unknown A
TBP-AE
TBBPA
HBCDs
Unknown B
NL: 1.21E5 m/z= 328.76310-328.76638 MS L6
NL: 7.18E1 Base Peak m/z= 306.87770-306.88076 MS L6
NL: 7.66E6 Base Peak m/z= 542.74245-542.74787 MS L6
NL: 2.36E5 Base Peak m/z= 640.63371-640.64011 MS L6
NL: 1.55E4 Base Peak m/z= 556.75961-556.76517 MS L6
Time (min)

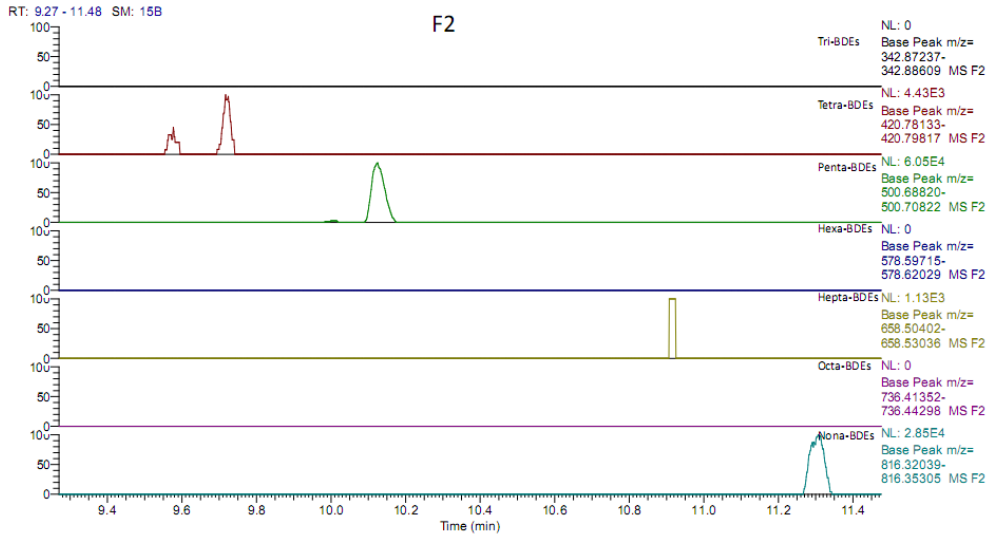

RT: 6.82 - 12.22 SM: 15B
BF
BTBPE
Unknown A
TBP-AE
TBBPA
HBCDs
Unknown B
NL: 4.15E4 m/z= 328.76310-328.76638 MS BF
NL: 2.15E2 Base Peak m/z= 306.87770-306.88076 MS BF
NL: 1.78E6 Base Peak m/z= 542.74245-542.74787 MS BF
NL: 8.49E2 Base Peak m/z= 640.63371-640.64011 MS BF
NL: 1.54E4 Base Peak m/z= 556.75961-556.76517 MS BF
Time (min)

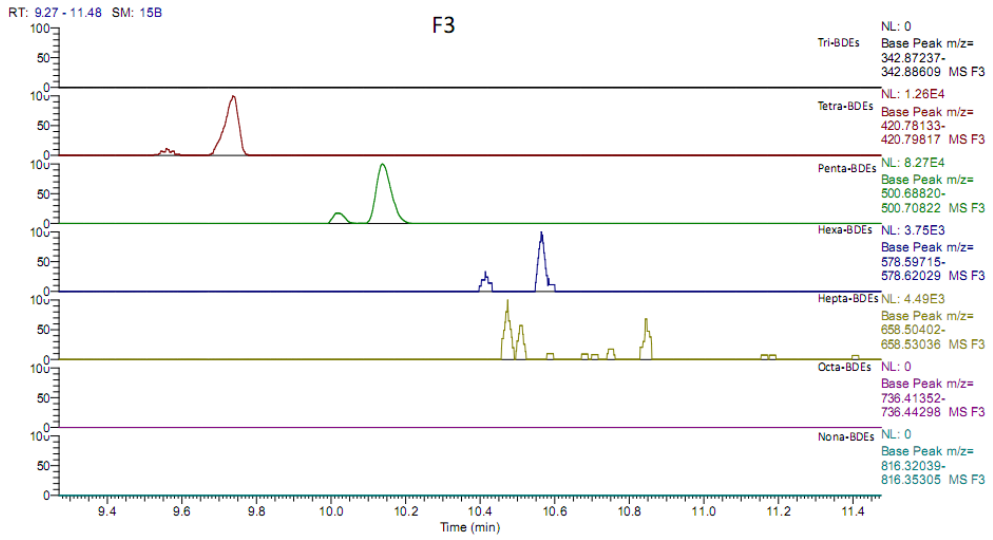

RT: 6.82 - 12.22 SM: 15B
BL
BTBPE
Unknown A
TBP-AE
TBBPA
HBCDs
Unknown B
NL: 4.00E4 m/z= 328.76310-328.76638 MS BL
NL: 4.09E2 Base Peak m/z= 306.87770-306.88076 MS BL
NL: 2.18E5 Base Peak m/z= 542.74245-542.74787 MS BL
NL: 0 Base Peak m/z= 640.63371-640.64011 MS BL
NL: 0 Base Peak m/z= 556.75961-556.76517 MS BL
Time (min)

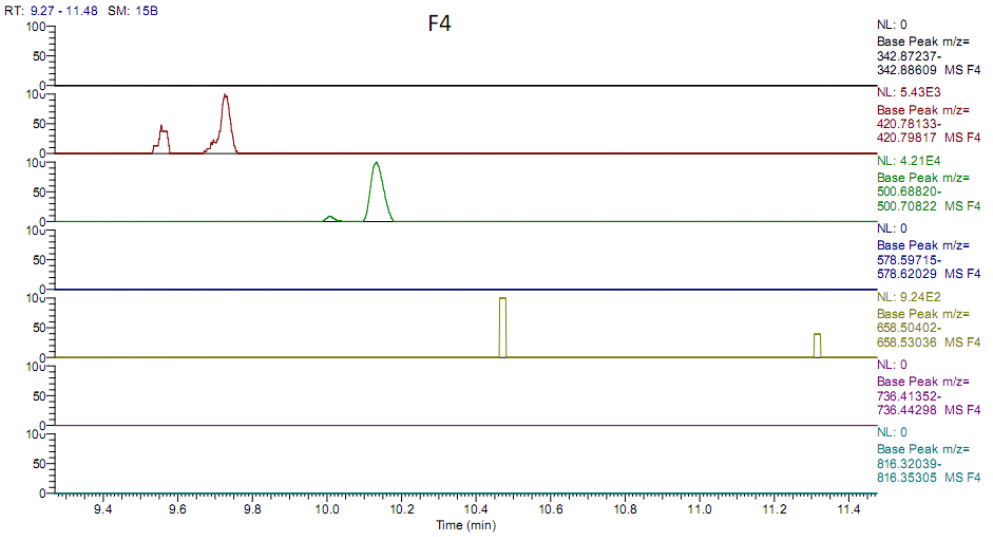

RT: 6.82 - 12.22 SM: 15B
Lab Blank
BTBPE
Unknown A
TBP-AE
TBBPA
HBCDs
Unknown B
NL:
4.67E3
m/z=
328.76310-
328.76638 MS
Blank3
NL:
0
Base Peak m/z=
306.87770-
306.88076 MS
Blank3
NL:
2.13E3
Base Peak m/z=
542.74245-
542.74787 MS
Blank3
NL:
0
Base Peak m/z=
640.63371-
640.64011 MS
Blank3
NL:
0
Base Peak m/z=
556.75961-
556.76517 MS
Blank3
Time (min)

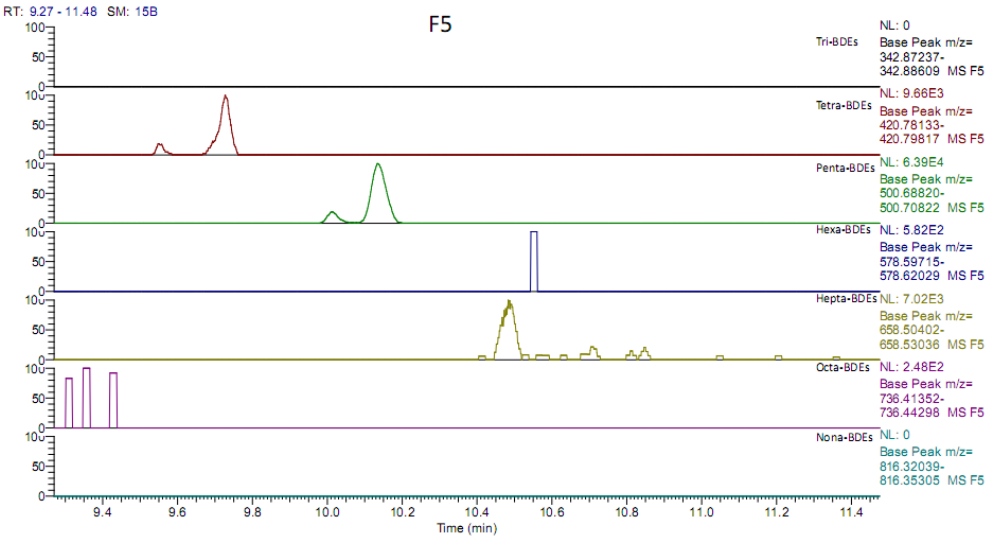
Appendix 4.2 PBDE homologues

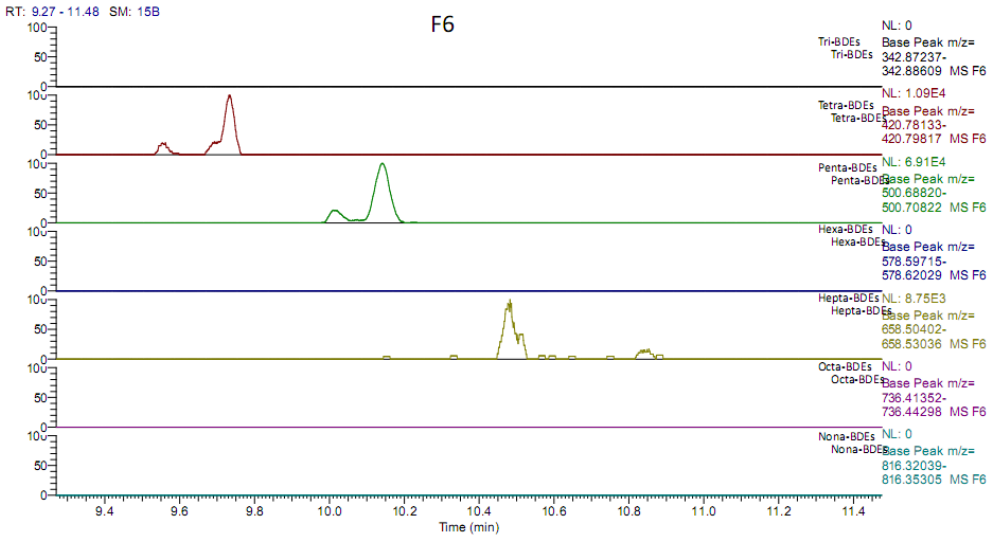


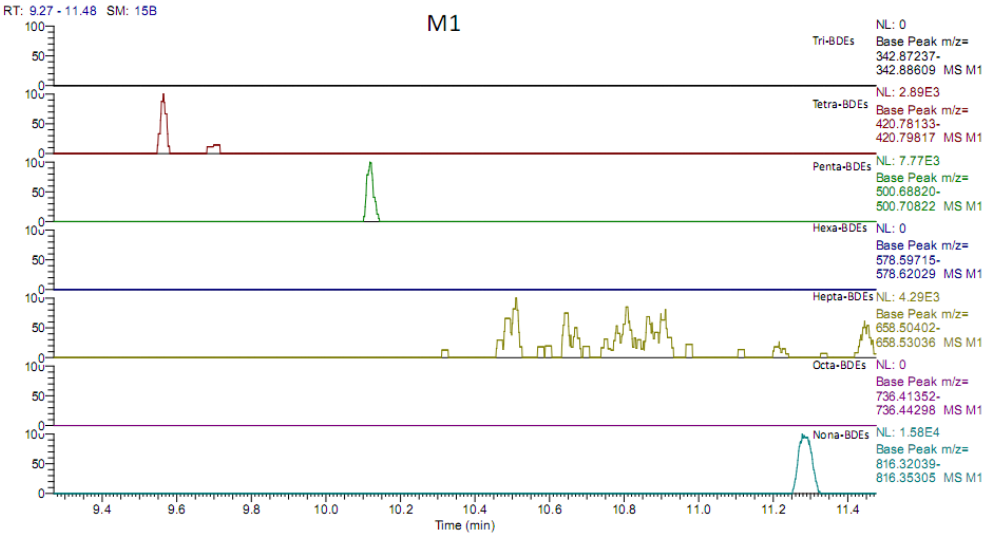


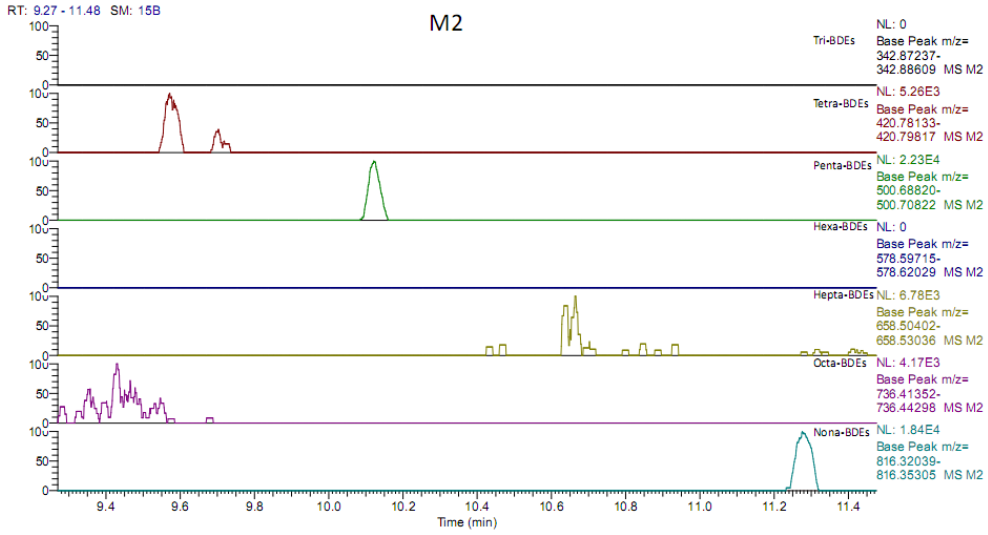


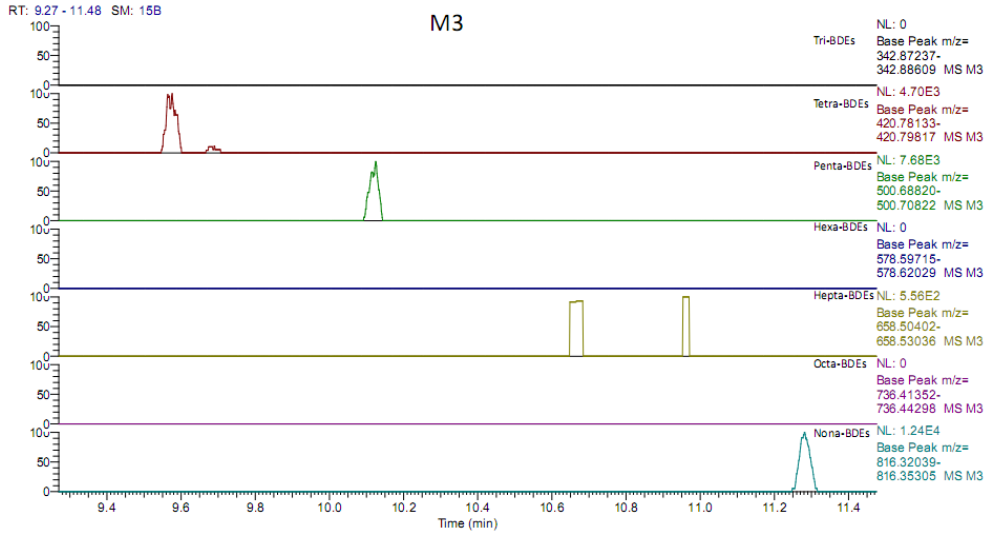

RT: 9.27 - 11.48 SM: 15B
F4
NL: 0
Base Peak m/z= 342.87237-342.88609 MS F4
NL: 5.43E3
Base Peak m/z= 420.78133-420.79817 MS F4
NL: 4.21E4
Base Peak m/z= 500.68820-500.70822 MS F4
NL: 0
Base Peak m/z= 578.59715-578.62029 MS F4
NL: 9.24E2
Base Peak m/z= 658.50402-658.53036 MS F4
NL: 0
Base Peak m/z= 736.41352-736.44298 MS F4
NL: 0
Base Peak m/z= 816.32039-816.35305 MS F4
Time (min)

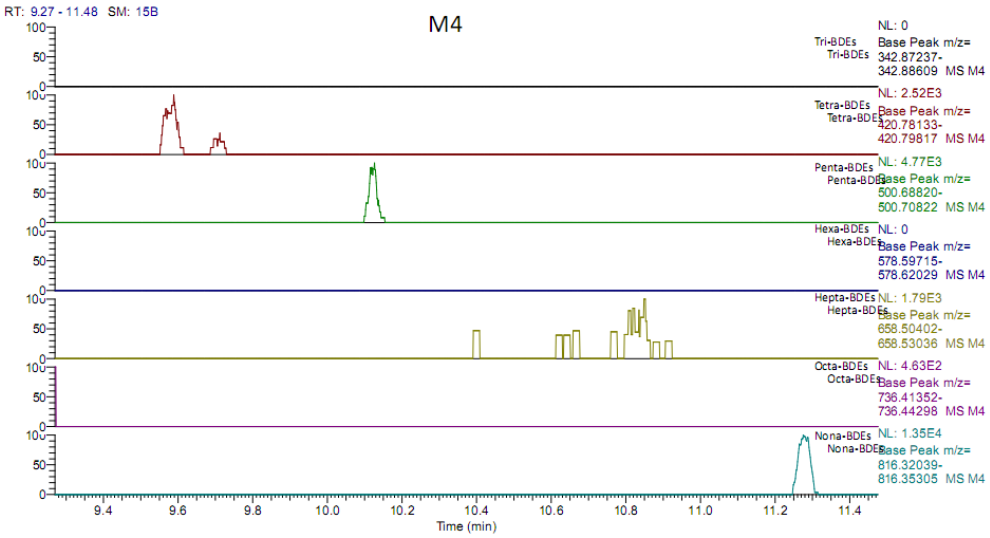

RT: 9.27 - 11.48 SM: 15B
F5
Tri-BDEs
NL: 0
Base Peak m/z= 342.87237-342.88609 MS F5
Tetra-BDEs
NL: 9.66E3
Base Peak m/z= 420.78133-420.79817 MS F5
Penta-BDEs
NL: 6.39E4
Base Peak m/z= 500.68820-500.70822 MS F5
Hexa-BDEs
NL: 5.82E2
Base Peak m/z= 578.59715-578.62029 MS F5
Hepta-BDEs
NL: 7.02E3
Base Peak m/z= 658.50402-658.53036 MS F5
Octa-BDEs
NL: 2.48E2
Base Peak m/z= 736.41352-736.44298 MS F5
Nona-BDEs
NL: 0
Base Peak m/z= 816.32039-816.35305 MS F5
Time (min)

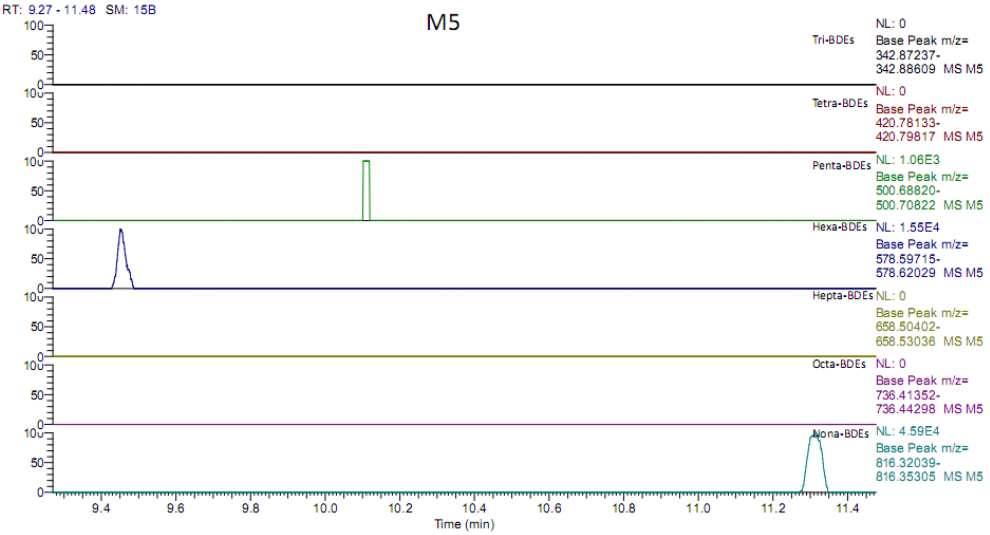

RT: 9.27 - 11.48 SM: 15B
F6
Tri-BDEs
NL: 0
Base Peak m/z= 342.87237-342.88609 MS F6
Tetra-BDEs
NL: 1.09E4
Base Peak m/z= 420.78133-420.79817 MS F6
Penta-BDEs
NL: 6.91E4
Base Peak m/z= 500.68820-500.70822 MS F6
Hexa-BDEs
NL: 0
Base Peak m/z= 578.59715-578.62029 MS F6
Hepta-BDEs
NL: 8.75E3
Base Peak m/z= 658.50402-658.53036 MS F6
Octa-BDEs
NL: 0
Base Peak m/z= 736.41352-736.44298 MS F6
Nona-BDEs
NL: 0
Base Peak m/z= 816.32039-816.35305 MS F6
Time (min)

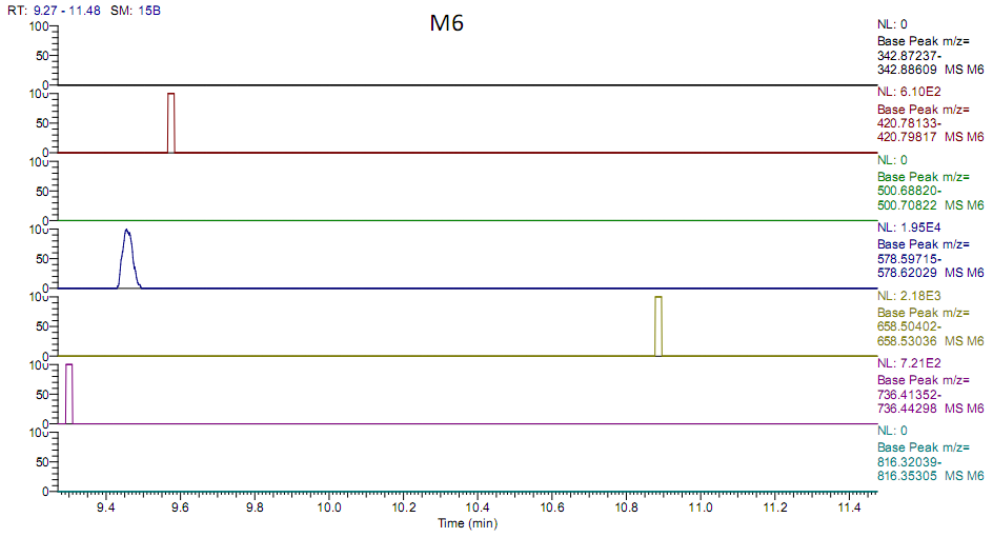

RT: 9.27 - 11.48 SM: 15B
M1
Tri-BDEs
NL: 0
Base Peak m/z= 342.87237-342.88609 MS M1
Tetra-BDEs
NL: 2.89E3
Base Peak m/z= 420.78133-420.79817 MS M1
Penta-BDEs
NL: 7.77E3
Base Peak m/z= 500.68820-500.70822 MS M1
Hexa-BDEs
NL: 0
Base Peak m/z= 578.59715-578.62029 MS M1
Hepta-BDEs
NL: 4.29E3
Base Peak m/z= 658.50402-658.53036 MS M1
Octa-BDEs
NL: 0
Base Peak m/z= 736.41352-736.44298 MS M1
Nona-BDEs
NL: 1.58E4
Base Peak m/z= 816.32039-816.35305 MS M1
Time (min)

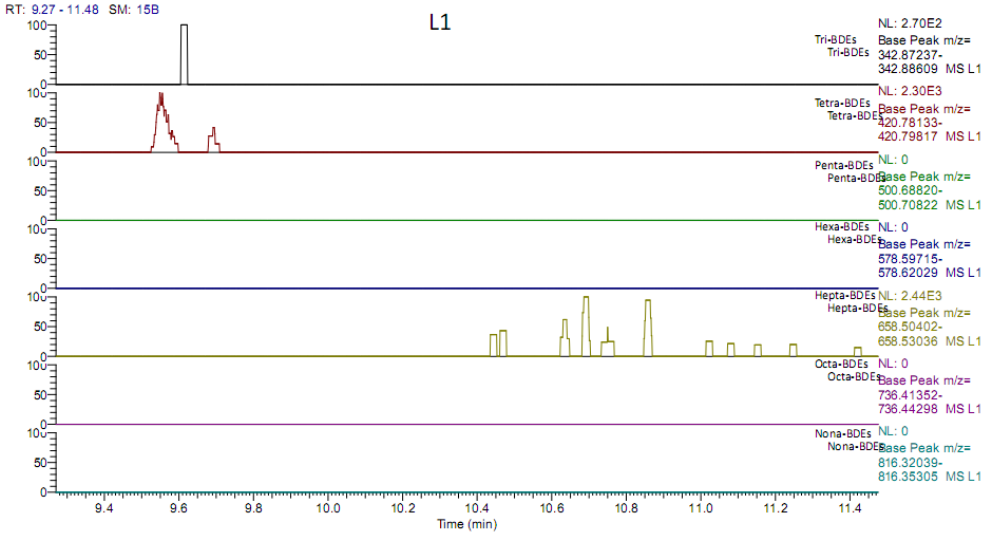

RT: 9.27 - 11.48 SM: 15B
M2
Tri-BDEs
NL: 0
Base Peak m/z= 342.87237-342.88609 MS M2
Tetra-BDEs
NL: 5.26E3
Base Peak m/z= 420.78133-420.79817 MS M2
Penta-BDEs
NL: 2.23E4
Base Peak m/z= 500.68820-500.70822 MS M2
Hexa-BDEs
NL: 0
Base Peak m/z= 578.59715-578.62029 MS M2
Hepta-BDEs
NL: 6.78E3
Base Peak m/z= 658.50402-658.53036 MS M2
Octa-BDEs
NL: 4.17E3
Base Peak m/z= 736.41352-736.44298 MS M2
Nona-BDEs
NL: 1.84E4
Base Peak m/z= 816.32039-816.35305 MS M2
Time (min)

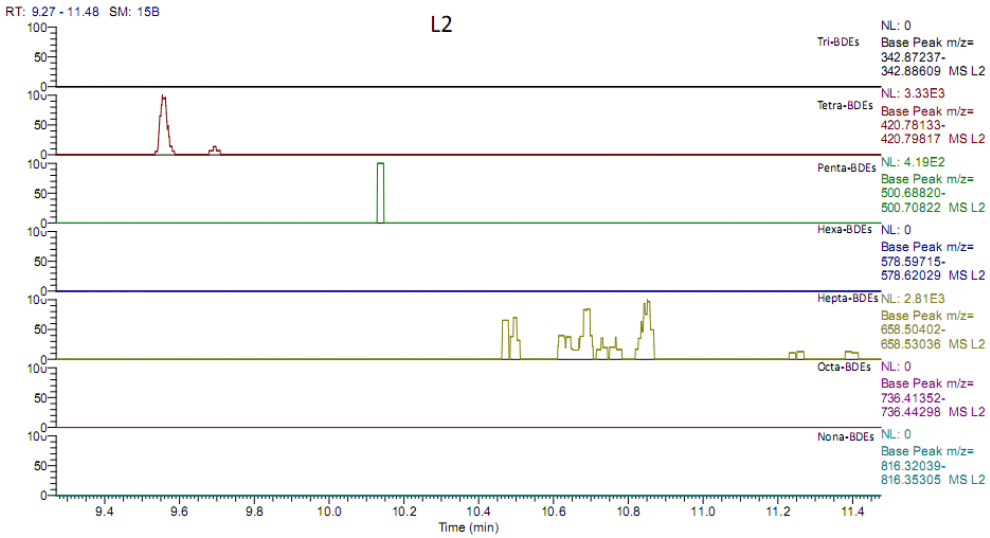

RT: 9.27 - 11.48 SM: 15B
M3
Tri-BDEs
NL: 0
Base Peak m/z= 342.87237-342.88609 MS M3
Tetra-BDEs
NL: 4.70E3
Base Peak m/z= 420.78133-420.79817 MS M3
Penta-BDEs
NL: 7.68E3
Base Peak m/z= 500.68820-500.70822 MS M3
Hexa-BDEs
NL: 0
Base Peak m/z= 578.59715-578.62029 MS M3
Hepta-BDEs
NL: 5.56E2
Base Peak m/z= 658.50402-658.53036 MS M3
Octa-BDEs
NL: 0
Base Peak m/z= 736.41352-736.44298 MS M3
Nona-BDEs
NL: 1.24E4
Base Peak m/z= 816.32039-816.35305 MS M3
Time (min)

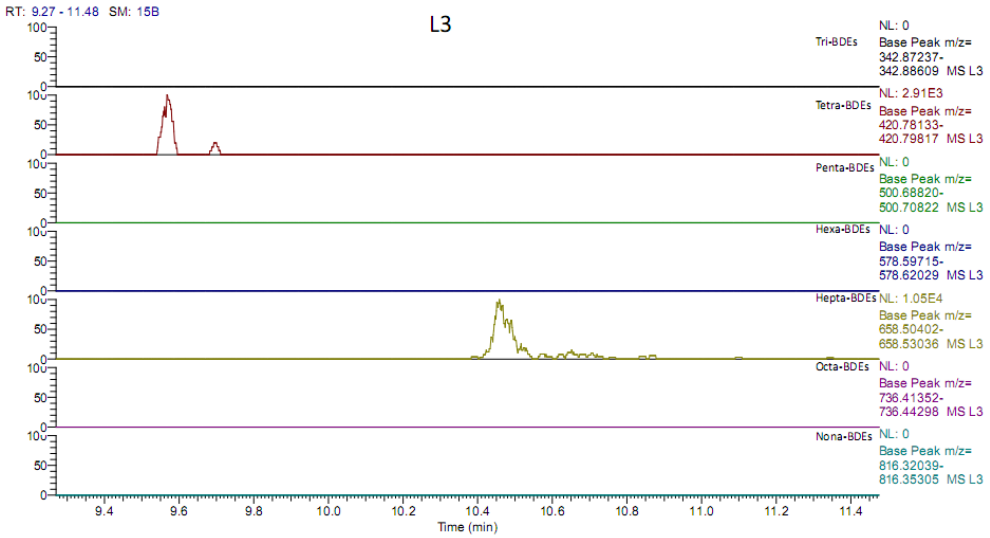

RT: 9.27 - 11.48 SM: 15B
M4
Tri-BDEs
Tetra-BDEs
Penta-BDEs
Hexa-BDEs
Hepta-BDEs
Octa-BDEs
Nona-BDEs
NL: 0
Base Peak m/z= 342.87237-342.88609 MS M4
NL: 2.52E3
Base Peak m/z= 420.78133-420.79817 MS M4
NL: 4.77E3
Base Peak m/z= 500.68820-500.70822 MS M4
NL: 0
Base Peak m/z= 578.59715-578.62029 MS M4
NL: 1.79E3
Base Peak m/z= 658.50402-658.53036 MS M4
NL: 4.63E2
Base Peak m/z= 736.41352-736.44298 MS M4
NL: 1.35E4
Base Peak m/z= 816.32039-816.35305 MS M4
Time (min)

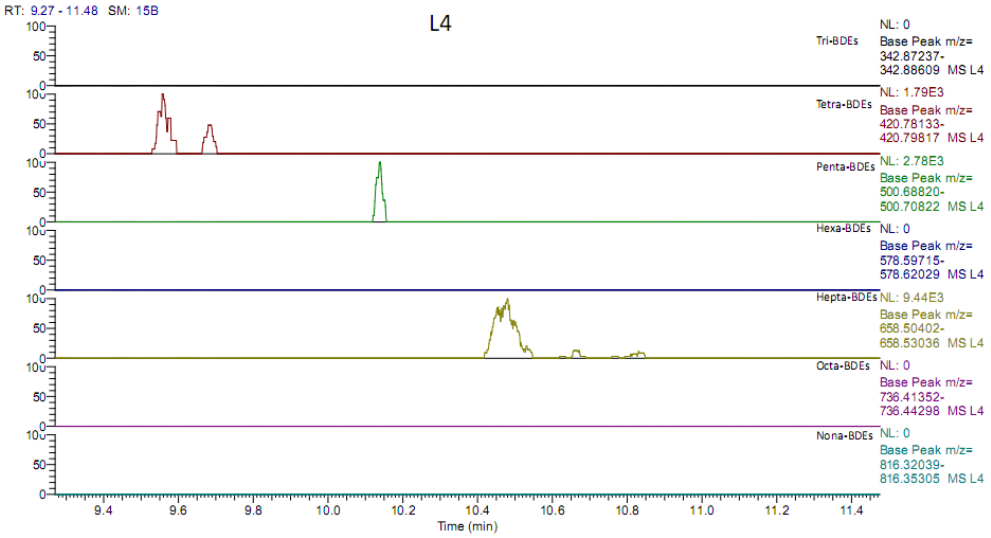

RT: 9.27 - 11.48 SM: 15B
M5
Tri-BDEs
Tetra-BDEs
Penta-BDEs
Hexa-BDEs
Hepta-BDEs
Octa-BDEs
Nona-BDEs
NL: 0
Base Peak m/z= 342.87237-342.88609 MS M5
NL: 0
Base Peak m/z= 420.78133-420.79817 MS M5
NL: 1.06E3
Base Peak m/z= 500.68820-500.70822 MS M5
NL: 1.55E4
Base Peak m/z= 578.59715-578.62029 MS M5
NL: 0
Base Peak m/z= 658.50402-658.53036 MS M5
NL: 0
Base Peak m/z= 736.41352-736.44298 MS M5
NL: 4.59E4
Base Peak m/z= 816.32039-816.35305 MS M5
Time (min)

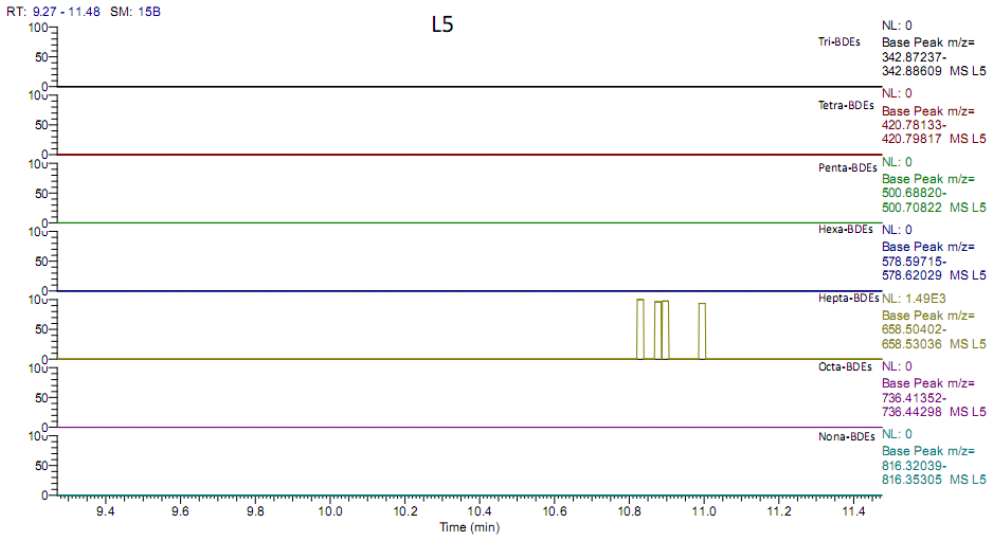

RT: 9.27 - 11.48 SM: 15B
M6
NL: 0
Base Peak m/z= 342.87237-342.88609 MS M6
NL: 6.10E2
Base Peak m/z= 420.78133-420.79817 MS M6
NL: 0
Base Peak m/z= 500.68820-500.70822 MS M6
NL: 1.95E4
Base Peak m/z= 578.59715-578.62029 MS M6
NL: 2.18E3
Base Peak m/z= 658.50402-658.53036 MS M6
NL: 7.21E2
Base Peak m/z= 736.41352-736.44298 MS M6
NL: 0
Base Peak m/z= 816.32039-816.35305 MS M6
Time (min)

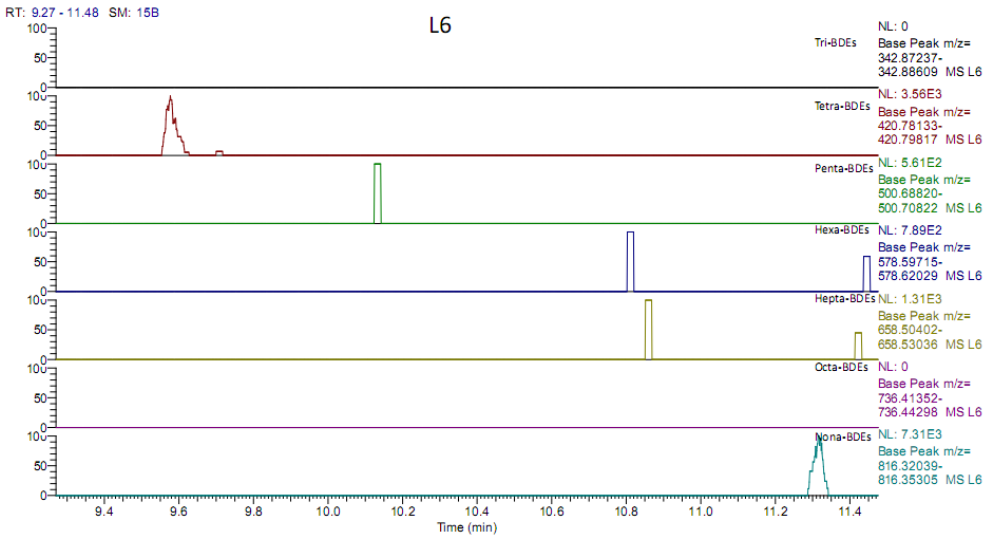

RT: 9.27 - 11.48 SM: 15B
L1
Tri-BDEs
Tri-BDEs
NL: 2.70E2
Base Peak m/z= 342.87237-342.88609 MS L1
Tetra-BDEs
Tetra-BDEs
NL: 2.30E3
Base Peak m/z= 420.78133-420.79817 MS L1
Penta-BDEs
Penta-BDEs
NL: 0
Base Peak m/z= 500.68820-500.70822 MS L1
Hexa-BDEs
Hexa-BDEs
NL: 0
Base Peak m/z= 578.59715-578.62029 MS L1
Hepta-BDEs
Hepta-BDEs
NL: 2.44E3
Base Peak m/z= 658.50402-658.53036 MS L1
Octa-BDEs
Octa-BDEs
NL: 0
Base Peak m/z= 736.41352-736.44298 MS L1
Nona-BDEs
Nona-BDEs
NL: 0
Base Peak m/z= 816.32039-816.35305 MS L1
Time (min)

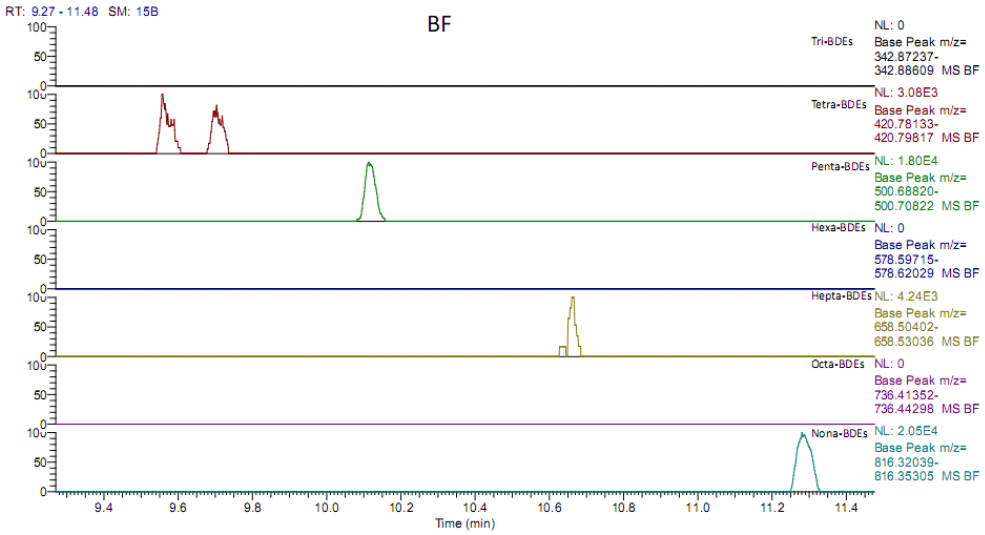

RT: 9.27 - 11.48 SM: 15B
L2
Tri-BDEs
NL: 0
Base Peak m/z= 342.87237-342.88609 MS L2
Tetra-BDEs
NL: 3.33E3
Base Peak m/z= 420.78133-420.79817 MS L2
Penta-BDEs
NL: 4.19E2
Base Peak m/z= 500.68820-500.70822 MS L2
Hexa-BDEs
NL: 0
Base Peak m/z= 578.59715-578.62029 MS L2
Hepta-BDEs
NL: 2.81E3
Base Peak m/z= 658.50402-658.53036 MS L2
Octa-BDEs
NL: 0
Base Peak m/z= 736.41352-736.44298 MS L2
Nona-BDEs
NL: 0
Base Peak m/z= 816.32039-816.35305 MS L2
Time (min)

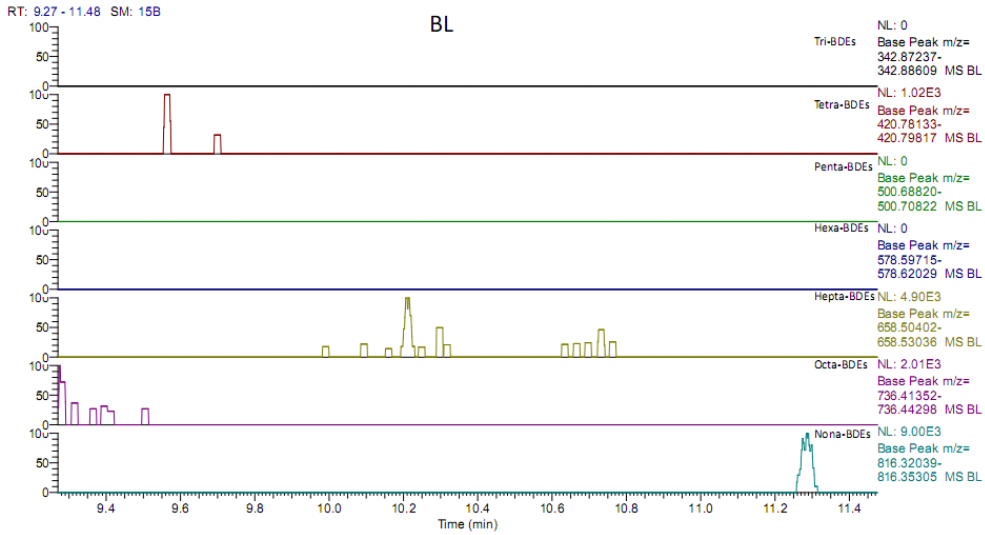

RT: 9.27 - 11.48 SM: 15B
L3
Tri-BDEs
NL: 0
Base Peak m/z= 342.87237-342.88609 MS L3
Tetra-BDEs
NL: 2.91E3
Base Peak m/z= 420.78133-420.79817 MS L3
Penta-BDEs
NL: 0
Base Peak m/z= 500.68820-500.70822 MS L3
Hexa-BDEs
NL: 0
Base Peak m/z= 578.59715-578.62029 MS L3
Hepta-BDEs
NL: 1.05E4
Base Peak m/z= 658.50402-658.53036 MS L3
Octa-BDEs
NL: 0
Base Peak m/z= 736.41352-736.44298 MS L3
Nona-BDEs
NL: 0
Base Peak m/z= 816.32039-816.35305 MS L3
Time (min)

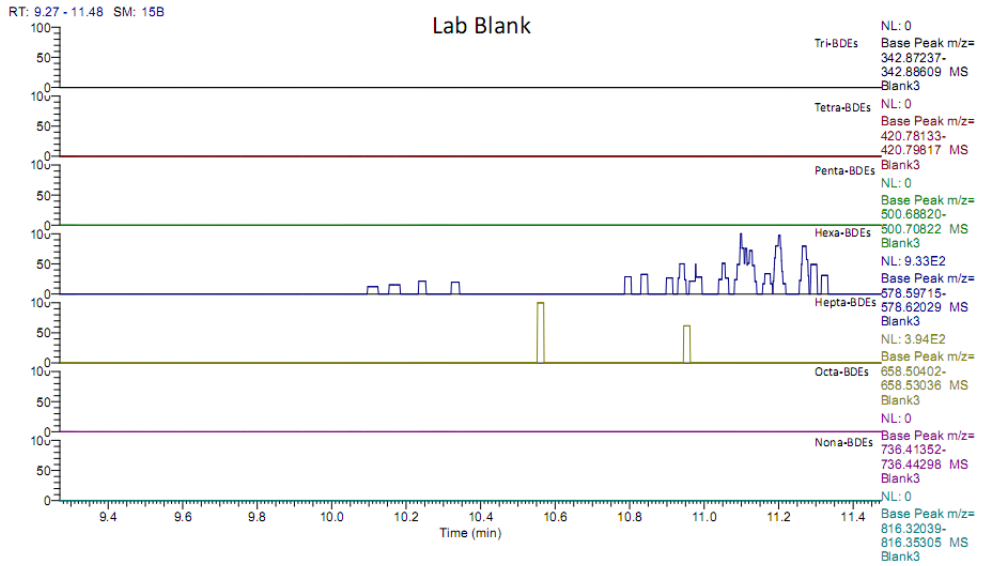

RT: 9.27 - 11.48 SM: 15B
L4
Tri-BDEs
NL: 0
Base Peak m/z= 342.87237-342.88609 MS L4
Tetra-BDEs
NL: 1.79E3
Base Peak m/z= 420.78133-420.79817 MS L4
Penta-BDEs
NL: 2.78E3
Base Peak m/z= 500.68820-500.70822 MS L4
Hexa-BDEs
NL: 0
Base Peak m/z= 578.59715-578.62029 MS L4
Hepta-BDEs
NL: 9.44E3
Base Peak m/z= 658.50402-658.53036 MS L4
Octa-BDEs
NL: 0
Base Peak m/z= 736.41352-736.44298 MS L4
Nona-BDEs
NL: 0
Base Peak m/z= 816.32039-816.35305 MS L4
Time (min)


RT: 9.27 - 11.48 SM: 15B
L5
Tri-BDEs
NL: 0
Base Peak m/z= 342.87237-342.88609 MS L5
Tetra-BDEs
NL: 0
Base Peak m/z= 420.78133-420.79817 MS L5
Penta-BDEs
NL: 0
Base Peak m/z= 500.68820-500.70822 MS L5
Hexa-BDEs
NL: 0
Base Peak m/z= 578.59715-578.62029 MS L5
Hepta-BDEs
NL: 1.49E3
Base Peak m/z= 658.50402-658.53036 MS L5
Octa-BDEs
NL: 0
Base Peak m/z= 736.41352-736.44298 MS L5
Nona-BDEs
NL: 0
Base Peak m/z= 816.32039-816.35305 MS L5
Time (min)


RT: 9.27 - 11.48 SM: 15B
L6
Tri-BDEs
NL: 0
Base Peak m/z= 342.87237-342.88609 MS L6
Tetra-BDEs
NL: 3.56E3
Base Peak m/z= 420.78133-420.79817 MS L6
Penta-BDEs
NL: 5.61E2
Base Peak m/z= 500.68820-500.70822 MS L6
Hexa-BDEs
NL: 7.89E2
Base Peak m/z= 578.59715-578.62029 MS L6
Hepta-BDEs
NL: 1.31E3
Base Peak m/z= 658.50402-658.53036 MS L6
Octa-BDEs
NL: 0
Base Peak m/z= 736.41352-736.44298 MS L6
Nona-BDEs
NL: 7.31E3
Base Peak m/z= 816.32039-816.35305 MS L6
Time (min)


RT: 9.27 - 11.48 SM: 15B
BF
Tri-BDEs
NL: 0
Base Peak m/z= 342.87237-342.88609 MS BF
Tetra-BDEs
NL: 3.08E3
Base Peak m/z= 420.78133-420.79817 MS BF
Penta-BDEs
NL: 1.80E4
Base Peak m/z= 500.68820-500.70822 MS BF
Hexa-BDEs
NL: 0
Base Peak m/z= 578.59715-578.62029 MS BF
Hepta-BDEs
NL: 4.24E3
Base Peak m/z= 658.50402-658.53036 MS BF
Octa-BDEs
NL: 0
Base Peak m/z= 736.41352-736.44298 MS BF
Nona-BDEs
NL: 2.05E4
Base Peak m/z= 816.32039-816.35305 MS BF
Time (min)


RT: 9.27 - 11.48 SM: 15B
BL
Tri-BDEs
NL: 0
Base Peak m/z= 342.87237-342.88609 MS BL
Tetra-BDEs
NL: 1.02E3
Base Peak m/z= 420.78133-420.79817 MS BL
Penta-BDEs
NL: 0
Base Peak m/z= 500.68820-500.70822 MS BL
Hexa-BDEs
NL: 0
Base Peak m/z= 578.59715-578.62029 MS BL
Hepta-BDEs
NL: 4.90E3
Base Peak m/z= 658.50402-658.53036 MS BL
Octa-BDEs
NL: 2.01E3
Base Peak m/z= 736.41352-736.44298 MS BL
Nona-BDEs
NL: 9.00E3
Base Peak m/z= 816.32039-816.35305 MS BL
Time (min)


RT: 9.27 - 11.48 SM: 15B
Lab Blank
Tri-BDEs
NL: 0
Base Peak m/z= 342.87237-342.88609 MS Blank3
Tetra-BDEs
NL: 0
Base Peak m/z= 420.78133-420.79817 MS Blank3
Penta-BDEs
NL: 0
Base Peak m/z= 500.68820-500.70822 MS Blank3
Hexa-BDEs
NL: 9.33E2
Base Peak m/z= 578.59715-578.62029 MS Blank3
Hepta-BDEs
NL: 3.94E2
Base Peak m/z= 658.50402-658.53036 MS Blank3
Octa-BDEs
NL: 0
Base Peak m/z= 736.41352-736.44298 MS Blank3
Nona-BDEs
NL: 0
Base Peak m/z= 816.32039-816.35305 MS Blank3
Time (min)

Appendix 5. Additional measurements of PFAS in 2022

Appendix 5.1 Introduction

In 2022, DEPA has contracted Danish Waste Solutions to carry out a supplementary set of tests focused on expanding the results of the 2016-project with data about the release of per- and polyfluoroalkyl substances (PFAS) from the three specific types of WEEE tested in the original project.

During the additional tests carried out in summer 2022, the original test set-up has been replicated to the largest possible extent. For details refer to the original report. The tested WEEE-types were:

- "Mixed-WEEE"; herein primarily small household appliances (e.g. blenders, boiling kettles and alike), computers, telephones etc.
- LCDs/CRTs
- Freezers/refrigerators

Appendix 5.2 Design of the leaching experiments

All three tests were carried out at AV Miljø (Hvidovre) using new 1000 L HDPE containers (IBC container with the top cut off). The test containers with "Mixed-WEEE", LCDs/CRTs, and freezers/refrigerators (= freezers/fridges) will henceforth be referred to as "M", "L" and "F/F", respectively.

All test containers were equipped with an outlet valve at the bottom and were slightly tilted towards the outlet valve in order to facilitate the collection of eluate and to ensure that there will be limited eluate build-up between the individual irrigation events. In case of freezers/refrigerators the test has been carried out on three single items each placed in different IBC container (referred to as F/F1, F/F2, and F/F3). The leachate from these three containers was then combined into a composite sample at each leaching step.

Appendix 5.3 Overview of different WEEE-items used in the three additional leaching tests in 2022

TABLE A5.1. List of WEEE items used in the additional leaching test in 2022

	Leaching test		
Item description	**"Mixed-WEEE"**	**"LCD/CRT"**	**"Refrigerator/Freezer"**
Computer	1	-	-
Water boiling kettle	3	-	-
Blender	2	-	-
Printer/scanner	2	-	-
Vacuum cleaner	2	-	-
VCR/DVD player	2	-	-
Computer keyboard	1	-	-

	Leaching test		
Item description	**“Mixed-WEEE”**	**“LCD/CRT”**	**“Refrigerator/Freezer”**
Notebook/laptop	3	-	-
Fax/telephone	2	-	-
Coffee machine	1	-	-
Toaster	2	-	-
Home foot spa machine	1	-	-
Modem	2	-	-
Cell phone	1	-	-
Radio/receiver	1		
Indoor heat pump	1		
Drone	1		
Indoor AC tower	1		
LCD screen	-	7	-
CRT screen	-	1	-
Refrigerator + freezer	-	-	3
Items, total count	**29**	**8**	**3**

Appendix 5.4 Irrigation scheme and sample collection

All three tests (M, L, and F/F) were carried out in a similar matter (Table A5.2).

TABLE A5.2. Irrigation scheme

Parameter	**Units**	**M**	**L**	**F/F (1,2,3)**
Test container	-	HDPE	HDPE	HDPE
Rain: “normal”	mm	40	40	40
Rain: “extreme”	mm	160	160	160
Irrigated surface	m^2	1.0	1.0	0.28/0.28/0.29
Volume: “normal”	litres per event	40	40	11.4/11.4/11.6
Volume: “extreme”	litres per event	160	160	45.5/45.5/46.8

First, the material in each test container was irrigated once a week with a predefined quantity of water which was equal to 40 l/m^2; i.e., one-fourth of the 160 mm/month precipitation which corresponds to the wettest month in the typical year. The 40 mm irrigation was referred to as “normal”. The eluate from each “normal” irrigation (#1 to #4) was collected from the bottom of the test container the following day. This set-up simulated up to 4 weeks of storage (with 4 individual rain events) without shelter prior to the collection. Next, the containers were lifted and moved around using a front loader and/or a fork lifter in order to “shake” the items a little (simulating transport). After being lowered again, the containers were irrigated after one week with an amount of water corresponding to the “normal” event (i.e., 40 mm precipitation), hence generating eluate #5. Then, after another week, the material in each test container was irrigated at once with a volume of water equivalent to one of the later year’s “extreme” rainfalls (i.e., 160 mm). The eluate (#6) was collected from the bottom of the container on the next day.

Two portions of each eluate sample were collected (“-1” and “-2”) and all eluates were stored at approximately 4 °C during the entire test period. The “-1” eluates were kept in the fridge as back-up while the “-2” eluates were sent to the analytical laboratory ALS Czech Republic.

Appendix 5.5 Eluate analysis

Two analytical methods were used for the measurement of various PFAS. First, a screening method with higher LOR[22] (referred to as W-PFCLMS02 in the laboratory reports; cf. Appendix 6) was used to analyse all samples and based on the results of this measurement (i.e. positive/negative) an ultra-low sensitive method (referred to as W-PFCLMS03 in the laboratory reports; cf. Appendix 6) may have be used where appropriate. Both methods were based on liquid chromatography with MS/MS detection. The following twenty-two compounds were included in both analytical rounds: Perfluorobutanoic acid (PFBA), Perfluoropentanoic acid (PFPeA), Perfluorohexanoic acid (PFHxA), Perfluoroheptanoic acid (PFHpA), Perfluorooctanoic acid (PFOA), Perfluorononanoic acid (PFNA), Perfluorodecanoic acid (PFDA), Perfluoroundecanoic acid (PFUnDA), Perfluorododecanoic acid (PFDoDA), Perfluorotridecanoic acid (PFTrDA), Perfluorobutane sulfonic acid (PFBS), Perfluoropentane sulfonic acid (PFPeS), Perfluorohexane sulfonic acid (PFHxS), Perfluoroheptane sulfonic acid (PFHpS), Perfluorooctane sulfonic acid (PFOS), Perfluorononane sulfonic acid (PFNS), Perfluorodecane sulfonic acid (PFDS), Perfluoroundecane sulfonic acid (PFUnDS), Perfluorododecane sulfonic acid (PFDoDS), Perfluorotridecane sulfonic acid (PFTrDS), 6:2 Fluorotelomer sulfonic acid (6:2 FTS), and Perfluorooctane sulfonamide (FOSA).

Appendix 5.6 Results of the PFAS analysis

The results of the PFAS measurements for demineralised water (DW) and a blank sample (Blank) are shown in Table A5.4 while the results for the “M”, “L” and “F/F” tests are shown in Table A5.5, A5.6 and A5.7, respectively.

The summation values of different compounds (i.e. sum of 4 PFAS and the sum of 22 PFAS) presented in the tables were calculated in accordance with the following principle: *“The value of LOR for the sum of parameters is equal to 50 % of the sum of the individual LODs. If any of the parameters included in the sum is above its LOR, the reported sum of parameters is based on a summation of all parameters above LOR, even though this result would be smaller than 50 % of the sum of the individual LORs.”*

An example of the calculation principle is provided in Table A5.3.

TABLE A5.3. Reporting rules for the summation parameters: examples

Parameter	LOR	Situation 1	Situation 2	Situation 3	Situation 4
A	1	*<1*	2	*<1*	2
B	2	*<2*	*<2*	3	3
C	3	*<3*	*<3*	4	*4*
D	4	*<4*	*<4*	5	*5*
Sum of A-D		<5	2	12	14

It should be mentioned that the laboratory noted significant matrix interferences in several eluate samples as well as foaming and odour issues. It is hypothesized that these might have been caused by washed out dust and/or organic impurities agglomerated inside some of the items (e.g. keyboards, printers, LCDs, computer ventilators, etc.). In that sense, many eluate samples produced in this project *visually* resembled more a landfill percolate rather than “clean” (rain)water which was in contact with WEEE. This has led to practical problems when using the ultra-sensitive equipment and necessary dilution of samples resulting in increased LORs in several cases.

[22] LOR = limit of reporting (also known as limit of quantification). As a rule of thumb LOR is limit of detection (LOD) times a safety factor selected by the laboratory.

As showed in Table A5.3, the demineralised water (DW) used for the tests was virtually PFAS-free while the blank sample contained 4.18 ng/l PFOS after 24 hours of contact between DW and the body of empty IBC-containers. Whether this amount of PFOS originated from the body of the IBC-containers or from an external contamination (e.g. dusts) is unknown.

TABLE A5.4. Solution concentrations of PFAS measured in DW and Blank

Parameter	LOD[a)]	Units	DW-2	Blank-2
pH	0.1	-	5.6	6.5
Perfluorobutanoic acid (PFBA)	2	ng/l	*<2*	*<2*
Perfluoropentanoic acid (PFPeA)	0.3	ng/l	*<0.3*	*<0.3*
Perfluorohexanoic acid (PFHxA)	0.3	ng/l	*<0.3*	*<0.3*
Perfluoroheptanoic acid (PFHpA)	0.3	ng/l	*<0.3*	*<0.3*
Perfluorooctanoic acid (PFOA)	0.3	ng/l	*<0.3*	*<0.3*
Perfluorononanoic acid (PFNA)	0.3	ng/l	*<0.3*	*<0.3*
Perfluorodecanoic acid (PFDA)	0.3	ng/l	*<0.3*	*<0.3*
Perfluoroundecanoic acid (PFUnDA)	0.3	ng/l	*<0.3*	*<0.3*
Perfluorododecanoic acid (PFDoDA)	0.3	ng/l	*<0.3*	*<0.3*
Perfluorotridecanoic acid (PFTrDA)	0.3	ng/l	*<0.3*	*<0.3*
Perfluorobutane sulfonic acid (PFBS)	0.3	ng/l	*<0.3*	*<0.3*
Perfluoropentane sulfonic acid (PFPeS)	0.3	ng/l	*<0.3*	*<0.3*
Perfluorohexane sulfonic acid (PFHxS)	0.3	ng/l	*<0.3*	*<0.3*
Perfluoroheptane sulfonic acid (PFHpS)	0.3	ng/l	*<0.3*	*<0.3*
Perfluorooctane sulfonic acid (PFOS)	0.3	ng/l	*<0.3*	4.18
Perfluorononane sulfonic acid (PFNS)	0.3	ng/l	*<0.3*	*<0.3*
Perfluorodecane sulfonic acid (PFDS)	0.3	ng/l	*<0.3*	*<0.3*
Perfluoroundecane sulfonic acid (PFUnDS)	1	ng/l	*<1*	*<1*
Perfluorododecane sulfonic acid (PFDoDS)	0.3	ng/l	*<0.3*	*<0.3*
Perfluorotridecane sulfonic acid (PFTrDS)	1	ng/l	*<1*	*<1*
6:2 Fluorotelomer sulfonic acid (6:2 FTS)	0.3	ng/l	*<0.3*	*<0.3*
Perfluorooctane sulfonamide (FOSA)	0.3	ng/l	*<0.3*	*<0.3*
Sum of 4 PFAS [b)]		ng/l	*<0.6*	4.18
Sum of 22 PFAS [b)]		ng/l	*<4.85*	4.18

[a)] Standard LOD of the ultra-low sensitive method (W-PFCLMS03) unless raised due to the matrix interferences

[b)] cf. Table A5.3 for details.

TABLE A5.5. Solution concentrations of PFOS/PFOA measured in eluates from mixed small WEEE

Parameter	M-1-2[a)]	M-2-2[a)]	M-3-2	M-4-2	M-5-2[a)]	M-6-2
pH	6.0	6.1	6.0	6.1	6.3	6.7
PFBA, ng/l	*<10*	*<11*	*<8*	*<8*	*<10*	*<24*
PFPeA, ng/l	*<10*	*<10*	*<1.2*	*<1.2*	*<10*	<4.8
PFHxA, ng/l	*<10*	*<10*	*<4.8*	*<2.4*	*<10*	2.79
PFHpA, ng/l	*<10*	*<10*	*<1.2*	*<1.2*	*<10*	1.66
PFOA, ng/l	11	8.3	8.58	10.4	*<5*	37.5
PFNA, ng/l	*<10*	*<10*	*<1.2*	*<1.2*	*<10*	*<1.2*
PFDA, ng/l	*<10*	*<10*	*<1.2*	*<1.2*	*<10*	2.43
PFUnDA, ng/l	*<10*	*<10*	*<1.2*	*<1.2*	*<10*	*<1.2*
PFDoDA, ng/l	*<10*	*<10*	*<1.2*	*<1.2*	*<10*	*<1.2*
PFTrDA, ng/l	*<10*	*<10*	*<1.2*	*<1.2*	*<10*	*<1.2*
PFBS, ng/l	163	109	44.2	74.8	81	23.2
PFPeS, ng/l	*<10*	*<10*	*<1.2*	*<1.2*	*<10*	*<1.2*
PFHxS, ng/l	*<10*	*<10*	*<1.2*	*<1.2*	*<10*	*<1.2*
PFHpS, ng/l	*<10*	*<10*	*<1.2*	*<1.2*	*<10*	*<1.2*
PFOS, ng/l	21.2	16.1	8.72	5.7	<5	44.8
PFNS, ng/l	*<10*	*<10*	*<1.2*	*<1.2*	*<10*	*<1.2*
PFDS, ng/l	*<10*	*<10*	*<1.2*	*<1.2*	*<10*	*<1.2*
PFUnDS, ng/l	*<10*	*<10*	*<4*	*<4*	*<10*	*<4*
PFDoDS, ng/l	*<10*	*<10*	*<1.2*	*<1.2*	*<10*	*<1.2*
PFTrDS, ng/l	*<20*	*<20*	*<4*	*<4*	*<20*	*<4*
6:2 FTS, ng/l	18	12	4.11	6.37	<10	2.92
FOSA, ng/l	*<10*	*<10*	*<1.2*	*<1.2*	*<10*	*<1.2*
Sum of 4 PFAS[b)], ng/l	32	24	17.3	16.1	<15	82.3
Sum of 22 PFAS[b)], ng/l	210	140	65.6	97.3	80	115

[a)] Measured using the W-PFCLMS02 method while the LOD had to be raised further due to matrix interferences.

[b)] cf. Table A5.3 for details.

TABLE A5.6. Solution concentrations of PFOS/PFOA measured in eluates from LCD/CRT

Parameter	L-1-2[a)]	L-2-2[a)]	L-3-2	L-4-2	L-5-2	L-6-2
pH	6.2	6.3	6.2	5.8	6.1	6.4
PFBA, ng/l	*<310*	*<120*	*<8*	*<8*	*<8*	*<8*
PFPeA, ng/l	*<10*	*<10*	*<2.4*	*<1.2*	*<1.2*	*<1.2*
PFHxA, ng/l	*<10*	*<10*	1.27	*<1.2*	*<2.4*	*<1.2*
PFHpA, ng/l	*<10*	*<10*	*<1.2*	*<1.2*	*<1.2*	*<1.2*
PFOA, ng/l	*<5*	*<5*	*<4.8*	*<1.2*	*<1.2*	2.25
PFNA, ng/l	58	15	10.1	10.8	6.52	17.6
PFDA, ng/l	*<10*	*<10*	*<1.2*	*<1.2*	*<1.2*	*<1.2*
PFUnDA, ng/l	35	*<10*	*<1.2*	*<1.2*	*<1.2*	8.87
PFDoDA, ng/l	*<10*	*<10*	*<1.2*	*<1.2*	*<1.2*	*<1.2*
PFTrDA, ng/l	*<10*	*<10*	*<1.2*	*<1.2*	*<1.2*	*<1.2*
PFBS, ng/l	226	233	80.3	73	32.1	13.2
PFPeS, ng/l	*<10*	*<10*	*<1.2*	*<1.2*	*<1.2*	*<1.2*
PFHxS, ng/l	*<10*	*<10*	*<1.2*	*<1.2*	*<1.2*	*<1.2*
PFHpS, ng/l	*<10*	*<10*	*<1.2*	*<1.2*	*<1.2*	*<1.2*
PFOS, ng/l	12.8	*<5*	2.54	4.26	2.42	29.8
PFNS, ng/l	*<10*	*<10*	*<1.2*	*<1.2*	*<1.2*	*<1.2*
PFDS, ng/l	*<10*	*<10*	*<1.2*	*<1.2*	*<1.2*	*<1.2*
PFUnDS, ng/l	*<10*	*<10*	*<4*	*<4*	*<4*	*<4*
PFDoDS, ng/l	*<10*	*<10*	*<1.2*	*<1.2*	*<1.2*	*<1.2*
PFTrDS, ng/l	*<20*	*<20*	*<4*	*<4*	*<4*	*<4*
6:2 FTS, ng/l	*<10*	*<10*	1.33	*<1.2*	*<1.2*	*<1.2*
FOSA, ng/l	*<10*	*<10*	*<1.2*	*<1.2*	*<1.2*	*<1.2*
Sum of 4 PFAS [b)], ng/l	71	15	12.6	15.1	8.94	49.6
Sum of 22 PFAS [b)], ng/l	330	250	95.5	88.1	41	71.7

[a)] Measured using the W-PFCLMS02 method while the LOD had to be raised due to matrix interferences.

[b)] cf. Table A5.3 for details.

TABLE A5.7. Solution concentrations of PFOS/PFOA measured in eluates from Fridges/freezers

Parameter	F/F-1-2	F/F-2-2	F/F-3-2	F/F-4-2	F/F-5-2	F/F-6-2
pH	6,4	6,3	6,1	5,9	6,4	6,5
PFBA, ng/l	*<8*	*<16*	*<60*	*<20*	*<60*	*<24*
PFPeA, ng/l	*<1,2*	*<31,2*	*<18*	*<18*	*<18*	*<60*
PFHxA, ng/l	2,3	*<4,8*	*<90*	*<90*	*<90*	*<96*
PFHpA, ng/l	3,35	4,84	*<9*	*<9*	*<9*	*<9,6*
PFOA, ng/l	22,3	27,3	5,87	2,02	3,57	2,8
PFNA, ng/l	*<1,2*	*<1,2*	0,58	0,45	<0,3	<1,2
PFDA, ng/l	1,9	1,22	0,8	0,42	0,37	1,2
PFUnDA, ng/l	*<1,2*	*<1,2*	*<0,3*	*0,33*	*<0,3*	*<1,2*
PFDoDA, ng/l	1,35	*<1,2*	*<0,3*	*<0,3*	*<0,3*	*<1,2*
PFTrDA, ng/l	*<1,2*	*<1,2*	*<0,3*	*<0,3*	*<0,3*	*<1,2*
PFBS, ng/l	4,8	4,8	6	15	9	24
PFPeS, ng/l	*<1,2*	*<1,2*	*<0,3*	*<0,3*	*<0,3*	*<1,2*
PFHxS, ng/l	1,36	*<1,2*	0,72	*<0,3*	*<0,3*	*<1,2*
PFHpS, ng/l	*<1,2*	*<1,2*	*<0,3*	*<0,3*	*<0,3*	*<1,2*
PFOS, ng/l	57,7	34,9	30,2	12,5	14	41
PFNS, ng/l	*<1,2*	*<1,2*	*<0,3*	*<0,3*	*<0,3*	*<1,2*
PFDS, ng/l	*<1,2*	*<1,2*	*<0,3*	*<0,3*	*<0,3*	*<1,2*
PFUnDS, ng/l	*<4*	*<4*	*<1*	*<1*	*<1*	*<4*
PFDoDS, ng/l	*<1,2*	*<1,2*	*<0,3*	*<0,3*	*<0,3*	*<1,2*
PFTrDS, ng/l	*<4*	*<4*	*<1*	*<1*	*<1*	*<4*
6:2 FTS, ng/l	*<1,2*	*<1,2*	0,38	*<0,3*	*<0,3*	*<1,2*
FOSA, ng/l	*<1,2*	*<1,2*	*<0,3*	*<0,3*	0,38	*<1,2*
Sum of 4 PFAS [a)], ng/l	81,4	62,2	37,4	15	17,6	43,8
Sum of 22 PFAS [a)], ng/l	90,3	68,3	38,6	15,7	18,3	43,8

[a)] cf. Table A5.3 for details.

According to the Statutory Order No 972 of 21/06/2022 on “Water quality and supervision of water supply facilities”, the original quality requirement for consumer taps of 0.1 µg/l (100 ng/l) still applies to the sum of 12 specified PFAS (i.e. PFBS, PFHxS, PFOS, PFOSA, 6:2 FTS, PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, and PFDA) while a new quality requirement of 0.002 µg/l (2 ng/l) applies to the sum of four PFAS (PFOA, PFNA, PFHxS, PFOS), which are a subset of the original 12.

It can be seen in Figure A5.1 that the quality requirement for the original QC (i.e. the sum of 12 PFAS) was exceeded in half of the eluates from “M” and several eluates from “L”. None of the “F/F” eluates exceeded this quality requirement value. On the other hand, the new QC value for the sum of 4 PFAS was exceeded in all eluates (Figure A5.2).

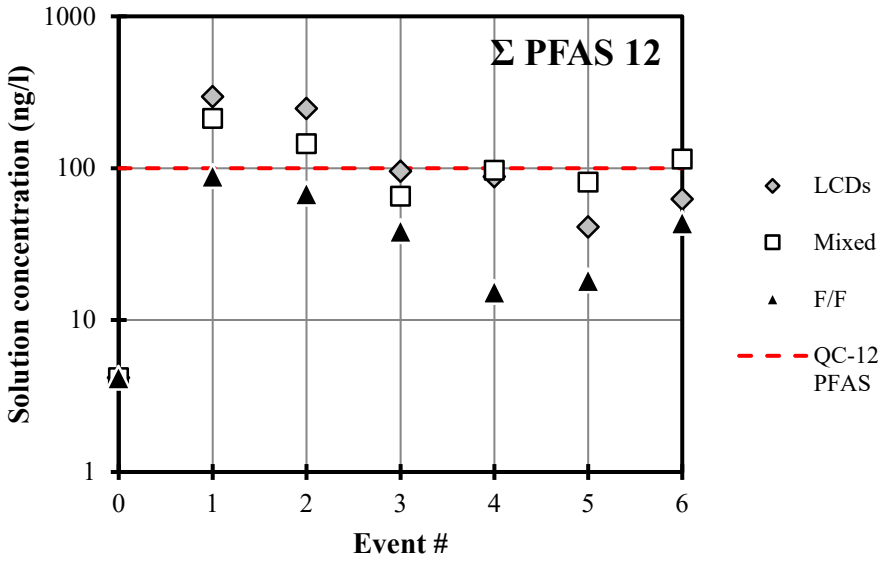


FIGURE A5.1. Solution concentrations of Σ PFAS 12 (PFBS, PFHxS, PFOS, PFOSA, 6:2 FTS, PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, and PFDA) in eluates from three different tests with WEEE.

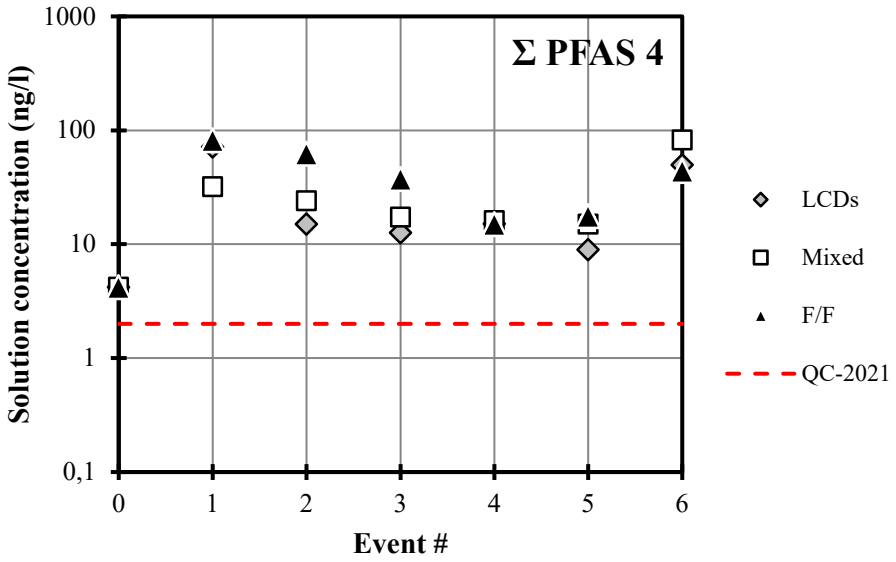


FIGURE A5.2. Solution concentrations of Σ PFAS 4 (PFOA, PFNA, PFHxS, PFOS) in eluates from three different tests with WEEE.

Appendix 6. Analytical reports – PFAS (2022)

This appendix includes the original analytical data for parameters determined during the additional study in 2022; i.e. twenty-two PFAS. For details refer to Appendix 5.

CERTIFICATE OF ANALYSIS

Work Order	: **PR2263014**	Issue Date	: 25-Jul-2022
Customer	: **Danish Waste Solutions**	Laboratory	: ALS Czech Republic, s.r.o.
Contact	: Jiří Hyks	Contact	: Client Service
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Telephone	: +45 26687051	Telephone	: +420 226 226 228
Project	: 2022-142	Page	: 1 of 11
Order number	: ----	Date Samples Received	: 23-Jun-2022
		Quote number	: PR2018DANWA-DK0001 (CZ-250-18-0344)
Site	: DK	Date of test	: 24-Jun-2022 - 25-Jul-2022
Sampled by	: client RMR	QC Level	: ALS CR Standard Quality Control Schedule

General Comments

This report shall not be reproduced except in full, without prior written approval from the laboratory.
The laboratory declares that the test results relate only to the listed samples. If the section "Sampled by" of the Certificate of analysis states: "Sampled by Customer" then the results relate to the sample as received.
Sample(s) PR2263014/004, 009, 010, method W-PFCLMS02 - LOR for particular sample(s) raised due to matrix interference.
Sample(s) PR2263014/005,006,008,011,013,015,016-020, method W-PFCLMS03 - LOR for particular sample(s) raised due to matrix interference.
Sample(s) PR2263014/020, method W-PFCLMS03 - LOR for particular sample(s) raised due to high concentration of determinated analytes.

Responsible for accuracy

Testing Laboratory No. 1163
Accredited by CAI according to
CSN EN ISO/IEC 17025:2018

Signatories		*Position*
Zdeněk Jirák		Environmental Business Unit Manager

L 1163

The company is certified according to ČSN EN ISO 14001 (Environmental management systems) and ČSN ISO 45001 (Occupational health and safety management systems)

Analytical Results

Sub-Matrix: **WATER**

Parameter	Method	LOR	Unit	Client sample ID: DW-2 (PR2263014001, 17-May-2022) Result	MU	Blank-2 (PR2263014002, 18-May-2022) Result	MU	M-1-2 (PR2263014003, 19-May-2022) Result	MU
Perfluorinated Compounds									
Perfluorobutanoic acid (PFBA)	W-PFCLMS03	2.0	ng/L	<2.0	----	<2.0	----	**----**	----
Perfluoropentanoic acid (PFPeA)	W-PFCLMS03	0.30	ng/L	<0.30	----	<0.30	----	**----**	----
Perfluorohexanoic acid (PFHxA)	W-PFCLMS03	0.30	ng/L	<0.30	----	<0.30	----	**----**	----
Perfluoroheptanoic acid (PFHpA)	W-PFCLMS03	0.30	ng/L	<0.30	----	<0.30	----	**----**	----
Perfluorooctanoic acid (PFOA)	W-PFCLMS03	0.30	ng/L	<0.30	----	<0.30	----	**----**	----
Perfluorononanoic acid (PFNA)	W-PFCLMS03	0.30	ng/L	<0.30	----	<0.30	----	**----**	----
Perfluorodecanoic acid (PFDA)	W-PFCLMS03	0.30	ng/L	<0.30	----	<0.30	----	**----**	----
Perfluoroundecanoic acid (PFUnDA)	W-PFCLMS03	0.30	ng/L	<0.30	----	<0.30	----	**----**	----
Perfluorododecanoic acid (PFDoDA)	W-PFCLMS03	0.30	ng/L	<0.30	----	<0.30	----	**----**	----
Sum of 4 PFAS (M1)	W-PFCLMS02	15	ng/L	**----**	----	**----**	----	**32**	± 40.0%
Perfluorotridecanoic acid (PFTrDA)	W-PFCLMS03	0.30	ng/L	<0.30	----	<0.30	----	**----**	----
Sum of 4 PFAS (M1)	W-PFCLMS03	0.60	ng/L	<0.60	----	**4.18**	± 40.0%	**----**	----
Perfluorobutane sulfonic acid (PFBS)	W-PFCLMS03	0.30	ng/L	<0.30	----	<0.30	----	**----**	----
Perfluoropentane sulfonic acid (PFPeS)	W-PFCLMS03	0.30	ng/L	<0.30	----	<0.30	----	**----**	----
Perfluorohexane sulfonic acid (PFHxS)	W-PFCLMS03	0.30	ng/L	<0.30	----	<0.30	----	**----**	----
Perfluoroheptane sulfonic acid (PFHpS)	W-PFCLMS03	0.30	ng/L	<0.30	----	<0.30	----	**----**	----
Perfluorooctane sulfonic acid (PFOS)	W-PFCLMS03	0.30	ng/L	<0.30	----	**4.18**	± 40.0%	**----**	----
Perfluorononane sulfonic acid (PFNS)	W-PFCLMS03	0.30	ng/L	<0.30	----	<0.30	----	**----**	----
Perfluorodecane sulfonic acid (PFDS)	W-PFCLMS03	0.30	ng/L	<0.30	----	<0.30	----	**----**	----
Perfluorododecane sulfonic acid (PFDoDS)	W-PFCLMS03	0.30	ng/L	<0.30	----	<0.30	----	**----**	----
6:2 Fluorotelomer sulfonic acid (6:2 FTS)	W-PFCLMS03	0.30	ng/L	<0.30	----	<0.30	----	**----**	----
Perfluoroundecane sulfonic acid (PFUnDS)	W-PFCLMS02	10	ng/L	**----**	----	**----**	----	<10	----
Perfluorooctane sulfonamide (FOSA)	W-PFCLMS03	0.30	ng/L	<0.30	----	<0.30	----	**----**	----
Perfluorotridecane sulfonic acid (PFTrDS)	W-PFCLMS02	20	ng/L	**----**	----	**----**	----	<20	----
Perfluorobutanoic acid (PFBA)	W-PFCLMS02	10	ng/L	**----**	----	**----**	----	<10	----
Perfluoropentanoic acid (PFPeA)	W-PFCLMS02	10	ng/L	**----**	----	**----**	----	<10	----
Perfluorohexanoic acid (PFHxA)	W-PFCLMS02	10	ng/L	**----**	----	**----**	----	<10	----
Perfluoroheptanoic acid (PFHpA)	W-PFCLMS02	10	ng/L	**----**	----	**----**	----	<10	----
Perfluorooctanoic acid (PFOA)	W-PFCLMS02	5.0	ng/L	**----**	----	**----**	----	**11.0**	± 30.0%
Perfluorononanoic acid (PFNA)	W-PFCLMS02	10	ng/L	**----**	----	**----**	----	<10	----
Perfluorodecanoic acid (PFDA)	W-PFCLMS02	10	ng/L	**----**	----	**----**	----	<10	----
Perfluoroundecanoic acid (PFUnDA)	W-PFCLMS02	10	ng/L	**----**	----	**----**	----	<10	----
Perfluorododecanoic acid (PFDoDA)	W-PFCLMS02	10	ng/L	**----**	----	**----**	----	<10	----
Perfluorotridecanoic acid (PFTrDA)	W-PFCLMS02	10	ng/L	**----**	----	**----**	----	<10	----
Perfluorobutane sulfonic acid (PFBS)	W-PFCLMS02	10	ng/L	**----**	----	**----**	----	**163**	± 30.0%
Perfluoropentane sulfonic acid (PFPeS)	W-PFCLMS02	10	ng/L	**----**	----	**----**	----	<10	----

Sub-Matrix: **WATER**				Client sample ID	**DW-2**		**Blank-2**		**M-1-2**	
				Laboratory sample ID	PR2263014001		PR2263014002		PR2263014003	
				Client sampling date / time	17-May-2022		18-May-2022		19-May-2022	
Parameter	*Method*	*LOR*	*Unit*	**Result**	**MU**	**Result**	**MU**	**Result**	**MU**
Perfluorinated Compounds - Continued									
Perfluorohexane sulfonic acid (PFHxS)	W-PFCLMS02	10	ng/L	**----**	----	**----**	----	<10	----
Perfluoroheptane sulfonic acid (PFHpS)	W-PFCLMS02	10	ng/L	**----**	----	**----**	----	<10	----
Perfluorooctane sulfonic acid (PFOS)	W-PFCLMS02	5.0	ng/L	**----**	----	**----**	----	**21.2**	± 30.0%
Perfluorononane sulfonic acid (PFNS)	W-PFCLMS02	10	ng/L	**----**	----	**----**	----	<10	----
Perfluorodecane sulfonic acid (PFDS)	W-PFCLMS02	10	ng/L	**----**	----	**----**	----	<10	----
Perfluorododecane sulfonic acid (PFDoDS)	W-PFCLMS02	10	ng/L	**----**	----	**----**	----	<10	----
6:2 Fluorotelomer sulfonic acid (6:2 FTS)	W-PFCLMS02	10	ng/L	**----**	----	**----**	----	**18**	± 40.0%
Perfluorooctane sulfonamide (FOSA)	W-PFCLMS02	10	ng/L	**----**	----	**----**	----	<10	----
Sum of 22 PFAS (M1)	W-PFCLMS02	110	ng/L	**----**	----	**----**	----	**210**	± 40.0%
Sum of 22 PFAS (M1)	W-PFCLMS03	4.85	ng/L	<4.85	----	**4.18**	± 40.0%	**----**	----
Perfluoroundecane sulfonic acid (PFUnDS)	W-PFCLMS03	1.0	ng/L	<1.0	----	<1.0	----	**----**	----
Perfluorotridecane sulfonic acid (PFTrDS)	W-PFCLMS03	1.0	ng/L	<1.0	----	<1.0	----	**----**	----
Physical Parameters									
Electrical Conductivity @ 25°C	W-CON-PCT	0.10	mS/m	**1.40**	± 10.0%	**5.90**	± 10.0%	**6.49**	± 10.0%
pH Value	W-PH-PCT	1.00	-	**5.57**	± 1.4%	**6.53**	± 1.2%	**6.04**	± 1.3%

Sub-Matrix: **WATER**				Client sample ID	**M-2-2**		**M-3-2**		**M-4-2**	
				Laboratory sample ID	PR2263014004		PR2263014005		PR2263014006	
				Client sampling date / time	25-May-2022		01-Jun-2022		08-Jun-2022	
Parameter	*Method*	*LOR*	*Unit*	**Result**	**MU**	**Result**	**MU**	**Result**	**MU**
Perfluorinated Compounds									
Perfluorobutanoic acid (PFBA)	W-PFCLMS03	2.0	ng/L	**----**	----	<8.0	----	<8.0	----
Perfluoropentanoic acid (PFPeA)	W-PFCLMS03	0.30	ng/L	**----**	----	<1.20	----	<1.20	----
Perfluorohexanoic acid (PFHxA)	W-PFCLMS03	0.30	ng/L	**----**	----	<4.80	----	<2.40	----
Perfluoroheptanoic acid (PFHpA)	W-PFCLMS03	0.30	ng/L	**----**	----	<1.20	----	<1.20	----
Perfluorooctanoic acid (PFOA)	W-PFCLMS03	0.30	ng/L	**----**	----	**8.58**	± 40.0%	**10.4**	± 40.0%
Perfluorononanoic acid (PFNA)	W-PFCLMS03	0.30	ng/L	**----**	----	<1.20	----	<1.20	----
Perfluorodecanoic acid (PFDA)	W-PFCLMS03	0.30	ng/L	**----**	----	<1.20	----	<1.20	----
Perfluoroundecanoic acid (PFUnDA)	W-PFCLMS03	0.30	ng/L	**----**	----	<1.20	----	<1.20	----
Perfluorododecanoic acid (PFDoDA)	W-PFCLMS03	0.30	ng/L	**----**	----	<1.20	----	<1.20	----
Sum of 4 PFAS (M1)	W-PFCLMS02	15	ng/L	**24**	± 40.0%	**----**	----	**----**	----
Perfluorotridecanoic acid (PFTrDA)	W-PFCLMS03	0.30	ng/L	**----**	----	<1.20	----	<1.20	----
Sum of 4 PFAS (M1)	W-PFCLMS03	0.60	ng/L	**----**	----	**17.3**	± 40.0%	**16.1**	± 40.0%
Perfluorobutane sulfonic acid (PFBS)	W-PFCLMS03	0.30	ng/L	**----**	----	**44.2**	± 40.0%	**74.8**	± 40.0%
Perfluoropentane sulfonic acid (PFPeS)	W-PFCLMS03	0.30	ng/L	**----**	----	<1.20	----	<1.20	----
Perfluorohexane sulfonic acid (PFHxS)	W-PFCLMS03	0.30	ng/L	**----**	----	<1.20	----	<1.20	----
Perfluoroheptane sulfonic acid (PFHpS)	W-PFCLMS03	0.30	ng/L	**----**	----	<1.20	----	<1.20	----
Perfluorooctane sulfonic acid (PFOS)	W-PFCLMS03	0.30	ng/L	**----**	----	**8.72**	± 40.0%	**5.70**	± 40.0%

Sub-Matrix: **WATER**

Parameter	Method	LOR	Unit	Client sample ID: M-2-2 Result	MU	Client sample ID: M-3-2 Result	MU	Client sample ID: M-4-2 Result	MU
				Laboratory sample ID: PR2263014004		Laboratory sample ID: PR2263014005		Laboratory sample ID: PR2263014006	
				Client sampling date / time: 25-May-2022		Client sampling date / time: 01-Jun-2022		Client sampling date / time: 08-Jun-2022	
Perfluorinated Compounds - Continued									
Perfluorononane sulfonic acid (PFNS)	W-PFCLMS03	0.30	ng/L	**----**	----	<1.20	----	<1.20	----
Perfluorodecane sulfonic acid (PFDS)	W-PFCLMS03	0.30	ng/L	**----**	----	<1.20	----	<1.20	----
Perfluorododecane sulfonic acid (PFDoDS)	W-PFCLMS03	0.30	ng/L	**----**	----	<1.20	----	<1.20	----
6:2 Fluorotelomer sulfonic acid (6:2 FTS)	W-PFCLMS03	0.30	ng/L	**----**	----	**4.11**	± 40.0%	**6.37**	± 40.0%
Perfluoroundecane sulfonic acid (PFUnDS)	W-PFCLMS02	10	ng/L	<10	----	**----**	----	**----**	----
Perfluorooctane sulfonamide (FOSA)	W-PFCLMS03	0.30	ng/L	**----**	----	<1.20	----	<1.20	----
Perfluorotridecane sulfonic acid (PFTrDS)	W-PFCLMS02	20	ng/L	<20	----	**----**	----	**----**	----
Perfluorobutanoic acid (PFBA)	W-PFCLMS02	10	ng/L	<11	----	**----**	----	**----**	----
Perfluoropentanoic acid (PFPeA)	W-PFCLMS02	10	ng/L	<10	----	**----**	----	**----**	----
Perfluorohexanoic acid (PFHxA)	W-PFCLMS02	10	ng/L	<10	----	**----**	----	**----**	----
Perfluoroheptanoic acid (PFHpA)	W-PFCLMS02	10	ng/L	<10	----	**----**	----	**----**	----
Perfluorooctanoic acid (PFOA)	W-PFCLMS02	5.0	ng/L	**8.3**	± 30.0%	**----**	----	**----**	----
Perfluorononanoic acid (PFNA)	W-PFCLMS02	10	ng/L	<10	----	**----**	----	**----**	----
Perfluorodecanoic acid (PFDA)	W-PFCLMS02	10	ng/L	<10	----	**----**	----	**----**	----
Perfluoroundecanoic acid (PFUnDA)	W-PFCLMS02	10	ng/L	<10	----	**----**	----	**----**	----
Perfluorododecanoic acid (PFDoDA)	W-PFCLMS02	10	ng/L	<10	----	**----**	----	**----**	----
Perfluorotridecanoic acid (PFTrDA)	W-PFCLMS02	10	ng/L	<10	----	**----**	----	**----**	----
Perfluorobutane sulfonic acid (PFBS)	W-PFCLMS02	10	ng/L	**109**	± 30.0%	**----**	----	**----**	----
Perfluoropentane sulfonic acid (PFPeS)	W-PFCLMS02	10	ng/L	<10	----	**----**	----	**----**	----
Perfluorohexane sulfonic acid (PFHxS)	W-PFCLMS02	10	ng/L	<10	----	**----**	----	**----**	----
Perfluoroheptane sulfonic acid (PFHpS)	W-PFCLMS02	10	ng/L	<10	----	**----**	----	**----**	----
Perfluorooctane sulfonic acid (PFOS)	W-PFCLMS02	5.0	ng/L	**16.1**	± 30.0%	**----**	----	**----**	----
Perfluorononane sulfonic acid (PFNS)	W-PFCLMS02	10	ng/L	<10	----	**----**	----	**----**	----
Perfluorodecane sulfonic acid (PFDS)	W-PFCLMS02	10	ng/L	<10	----	**----**	----	**----**	----
Perfluorododecane sulfonic acid (PFDoDS)	W-PFCLMS02	10	ng/L	<10	----	**----**	----	**----**	----
6:2 Fluorotelomer sulfonic acid (6:2 FTS)	W-PFCLMS02	10	ng/L	**12**	± 40.0%	**----**	----	**----**	----
Perfluorooctane sulfonamide (FOSA)	W-PFCLMS02	10	ng/L	<10	----	**----**	----	**----**	----
Sum of 22 PFAS (M1)	W-PFCLMS02	110	ng/L	**140**	± 40.0%	**----**	----	**----**	----
Sum of 22 PFAS (M1)	W-PFCLMS03	4.85	ng/L	**----**	----	**65.6**	± 40.0%	**97.3**	± 40.0%
Perfluoroundecane sulfonic acid (PFUnDS)	W-PFCLMS03	1.0	ng/L	**----**	----	<4.0	----	<4.0	----
Perfluorotridecane sulfonic acid (PFTrDS)	W-PFCLMS03	1.0	ng/L	**----**	----	<4.0	----	<4.0	----
Physical Parameters									
Electrical Conductivity @ 25°C	W-CON-PCT	0.10	mS/m	**4.57**	± 10.0%	**3.65**	± 10.0%	**3.06**	± 10.0%
pH Value	W-PH-PCT	1.00	-	**6.05**	± 1.3%	**5.97**	± 1.3%	**6.06**	± 1.3%

Sub-Matrix: **WATER**

Client sample ID	M-5-2	M-6-2	L-1-2

Sub-Matrix: **WATER**

				Client sample ID	M-5-2		M-6-2		L-1-2	
				Laboratory sample ID	PR2263014007		PR2263014008		PR2263014009	
				Client sampling date / time	15-Jun-2022		22-Jun-2022		19-May-2022	
Parameter	*Method*	*LOR*	*Unit*		**Result**	**MU**	**Result**	**MU**	**Result**	**MU**
Perfluorinated Compounds										
Perfluorobutanoic acid (PFBA)	W-PFCLMS03	2.0	ng/L		**----**	----	<24.0	----	**----**	----
Perfluoropentanoic acid (PFPeA)	W-PFCLMS03	0.30	ng/L		**----**	----	<4.80	----	**----**	----
Perfluorohexanoic acid (PFHxA)	W-PFCLMS03	0.30	ng/L		**----**	----	**2.79**	± 40.0%	**----**	----
Perfluoroheptanoic acid (PFHpA)	W-PFCLMS03	0.30	ng/L		**----**	----	**1.66**	± 40.0%	**----**	----
Perfluorooctanoic acid (PFOA)	W-PFCLMS03	0.30	ng/L		**----**	----	**37.5**	± 40.0%	**----**	----
Perfluorononanoic acid (PFNA)	W-PFCLMS03	0.30	ng/L		**----**	----	<1.20	----	**----**	----
Perfluorodecanoic acid (PFDA)	W-PFCLMS03	0.30	ng/L		**----**	----	**2.43**	± 40.0%	**----**	----
Perfluoroundecanoic acid (PFUnDA)	W-PFCLMS03	0.30	ng/L		**----**	----	<1.20	----	**----**	----
Perfluorododecanoic acid (PFDoDA)	W-PFCLMS03	0.30	ng/L		**----**	----	<1.20	----	**----**	----
Sum of 4 PFAS (M1)	W-PFCLMS02	15	ng/L		<15	----	**----**	----	**71**	± 40.0%
Perfluorotridecanoic acid (PFTrDA)	W-PFCLMS03	0.30	ng/L		**----**	----	<1.20	----	**----**	----
Sum of 4 PFAS (M1)	W-PFCLMS03	0.60	ng/L		**----**	----	**82.3**	± 40.0%	**----**	----
Perfluorobutane sulfonic acid (PFBS)	W-PFCLMS03	0.30	ng/L		**----**	----	**23.2**	± 40.0%	**----**	----
Perfluoropentane sulfonic acid (PFPeS)	W-PFCLMS03	0.30	ng/L		**----**	----	<1.20	----	**----**	----
Perfluorohexane sulfonic acid (PFHxS)	W-PFCLMS03	0.30	ng/L		**----**	----	<1.20	----	**----**	----
Perfluoroheptane sulfonic acid (PFHpS)	W-PFCLMS03	0.30	ng/L		**----**	----	<1.20	----	**----**	----
Perfluorooctane sulfonic acid (PFOS)	W-PFCLMS03	0.30	ng/L		**----**	----	**44.8**	± 40.0%	**----**	----
Perfluorononane sulfonic acid (PFNS)	W-PFCLMS03	0.30	ng/L		**----**	----	<1.20	----	**----**	----
Perfluorodecane sulfonic acid (PFDS)	W-PFCLMS03	0.30	ng/L		**----**	----	<1.20	----	**----**	----
Perfluorododecane sulfonic acid (PFDoDS)	W-PFCLMS03	0.30	ng/L		**----**	----	<1.20	----	**----**	----
6:2 Fluorotelomer sulfonic acid (6:2 FTS)	W-PFCLMS03	0.30	ng/L		**----**	----	**2.92**	± 40.0%	**----**	----
Perfluoroundecane sulfonic acid (PFUnDS)	W-PFCLMS02	10	ng/L		<10	----	**----**	----	<10	----
Perfluorooctane sulfonamide (FOSA)	W-PFCLMS03	0.30	ng/L		**----**	----	<1.20	----	**----**	----
Perfluorotridecane sulfonic acid (PFTrDS)	W-PFCLMS02	20	ng/L		<20	----	**----**	----	<20	----
Perfluorobutanoic acid (PFBA)	W-PFCLMS02	10	ng/L		<10	----	**----**	----	<310	----
Perfluoropentanoic acid (PFPeA)	W-PFCLMS02	10	ng/L		<10	----	**----**	----	<10	----
Perfluorohexanoic acid (PFHxA)	W-PFCLMS02	10	ng/L		<10	----	**----**	----	<10	----
Perfluoroheptanoic acid (PFHpA)	W-PFCLMS02	10	ng/L		<10	----	**----**	----	<10	----
Perfluorooctanoic acid (PFOA)	W-PFCLMS02	5.0	ng/L		<5.0	----	**----**	----	<5.0	----
Perfluorononanoic acid (PFNA)	W-PFCLMS02	10	ng/L		<10	----	**----**	----	**58**	± 30.0%
Perfluorodecanoic acid (PFDA)	W-PFCLMS02	10	ng/L		<10	----	**----**	----	<10	----
Perfluoroundecanoic acid (PFUnDA)	W-PFCLMS02	10	ng/L		<10	----	**----**	----	**35**	± 40.0%
Perfluorododecanoic acid (PFDoDA)	W-PFCLMS02	10	ng/L		<10	----	**----**	----	<10	----
Perfluorotridecanoic acid (PFTrDA)	W-PFCLMS02	10	ng/L		<10	----	**----**	----	<10	----
Perfluorobutane sulfonic acid (PFBS)	W-PFCLMS02	10	ng/L		**81**	± 30.0%	**----**	----	**226**	± 30.0%
Perfluoropentane sulfonic acid (PFPeS)	W-PFCLMS02	10	ng/L		<10	----	**----**	----	<10	----
Perfluorohexane sulfonic acid (PFHxS)	W-PFCLMS02	10	ng/L		<10	----	**----**	----	<10	----

Sub-Matrix: **WATER**

	Client sample ID	M-5-2		M-6-2		L-1-2	
	Laboratory sample ID	PR2263014007		PR2263014008		PR2263014009	
	Client sampling date / time	15-Jun-2022		22-Jun-2022		19-May-2022	
Parameter	Method / LOR / Unit	Result	MU	Result	MU	Result	MU
Perfluorinated Compounds - Continued							
Perfluoroheptane sulfonic acid (PFHpS)	W-PFCLMS02 / 10 / ng/L	<10	----	**----**	----	<10	----
Perfluorooctane sulfonic acid (PFOS)	W-PFCLMS02 / 5.0 / ng/L	<5.0	----	**----**	----	**12.8**	± 30.0%
Perfluorononane sulfonic acid (PFNS)	W-PFCLMS02 / 10 / ng/L	<10	----	**----**	----	<10	----
Perfluorodecane sulfonic acid (PFDS)	W-PFCLMS02 / 10 / ng/L	<10	----	**----**	----	<10	----
Perfluorododecane sulfonic acid (PFDoDS)	W-PFCLMS02 / 10 / ng/L	<10	----	**----**	----	<10	----
6:2 Fluorotelomer sulfonic acid (6:2 FTS)	W-PFCLMS02 / 10 / ng/L	<10	----	**----**	----	<10	----
Perfluorooctane sulfonamide (FOSA)	W-PFCLMS02 / 10 / ng/L	<10	----	**----**	----	<10	----
Sum of 22 PFAS (M1)	W-PFCLMS02 / 110 / ng/L	**80**	± 40.0%	**----**	----	**330**	± 40.0%
Sum of 22 PFAS (M1)	W-PFCLMS03 / 4.85 / ng/L	**----**	----	**115**	± 40.0%	**----**	----
Perfluoroundecane sulfonic acid (PFUnDS)	W-PFCLMS03 / 1.0 / ng/L	**----**	----	<4.0	----	**----**	----
Perfluorotridecane sulfonic acid (PFTrDS)	W-PFCLMS03 / 1.0 / ng/L	**----**	----	<4.0	----	**----**	----
Physical Parameters							
Electrical Conductivity @ 25°C	W-CON-PCT / 0.10 / mS/m	**2.61**	± 10.0%	**9.96**	± 10.0%	**6.09**	± 10.0%
pH Value	W-PH-PCT / 1.00 / -	**6.25**	± 1.3%	**6.74**	± 1.2%	**6.16**	± 1.3%

Sub-Matrix: **WATER**

	Client sample ID	L-2-2		L-3-2		L-4-2	
	Laboratory sample ID	PR2263014010		PR2263014011		PR2263014012	
	Client sampling date / time	25-May-2022		01-Jun-2022		08-Jun-2022	
Parameter	Method / LOR / Unit	Result	MU	Result	MU	Result	MU
Perfluorinated Compounds							
Perfluorobutanoic acid (PFBA)	W-PFCLMS03 / 2.0 / ng/L	**----**	----	<8.0	----	<8.0	----
Perfluoropentanoic acid (PFPeA)	W-PFCLMS03 / 0.30 / ng/L	**----**	----	<2.40	----	<1.20	----
Perfluorohexanoic acid (PFHxA)	W-PFCLMS03 / 0.30 / ng/L	**----**	----	**1.27**	± 40.0%	<1.20	----
Perfluoroheptanoic acid (PFHpA)	W-PFCLMS03 / 0.30 / ng/L	**----**	----	<1.20	----	<1.20	----
Perfluorooctanoic acid (PFOA)	W-PFCLMS03 / 0.30 / ng/L	**----**	----	<4.80	----	<1.20	----
Perfluorononanoic acid (PFNA)	W-PFCLMS03 / 0.30 / ng/L	**----**	----	**10.1**	± 40.0%	**10.8**	± 40.0%
Perfluorodecanoic acid (PFDA)	W-PFCLMS03 / 0.30 / ng/L	**----**	----	<1.20	----	<1.20	----
Perfluoroundecanoic acid (PFUnDA)	W-PFCLMS03 / 0.30 / ng/L	**----**	----	<1.20	----	<1.20	----
Perfluorododecanoic acid (PFDoDA)	W-PFCLMS03 / 0.30 / ng/L	**----**	----	<1.20	----	<1.20	----
Sum of 4 PFAS (M1)	W-PFCLMS02 / 15 / ng/L	**15**	± 40.0%	**----**	----	**----**	----
Perfluorotridecanoic acid (PFTrDA)	W-PFCLMS03 / 0.30 / ng/L	**----**	----	<1.20	----	<1.20	----
Sum of 4 PFAS (M1)	W-PFCLMS03 / 0.60 / ng/L	**----**	----	**12.6**	± 40.0%	**15.1**	± 40.0%
Perfluorobutane sulfonic acid (PFBS)	W-PFCLMS03 / 0.30 / ng/L	**----**	----	**80.3**	± 40.0%	**73.0**	± 40.0%
Perfluoropentane sulfonic acid (PFPeS)	W-PFCLMS03 / 0.30 / ng/L	**----**	----	<1.20	----	<1.20	----
Perfluorohexane sulfonic acid (PFHxS)	W-PFCLMS03 / 0.30 / ng/L	**----**	----	<1.20	----	<1.20	----
Perfluoroheptane sulfonic acid (PFHpS)	W-PFCLMS03 / 0.30 / ng/L	**----**	----	<1.20	----	<1.20	----
Perfluorooctane sulfonic acid (PFOS)	W-PFCLMS03 / 0.30 / ng/L	**----**	----	**2.54**	± 40.0%	**4.26**	± 40.0%
Perfluorononane sulfonic acid (PFNS)	W-PFCLMS03 / 0.30 / ng/L	**----**	----	<1.20	----	<1.20	----

Sub-Matrix: **WATER**

Parameter	Method	LOR	Unit	Client sample ID: L-2-2 / Laboratory sample ID: PR2263014010 / Client sampling date / time: 25-May-2022		Client sample ID: L-3-2 / Laboratory sample ID: PR2263014011 / Client sampling date / time: 01-Jun-2022		Client sample ID: L-4-2 / Laboratory sample ID: PR2263014012 / Client sampling date / time: 08-Jun-2022	
				Result	MU	Result	MU	Result	MU
Perfluorinated Compounds - Continued									
Perfluorodecane sulfonic acid (PFDS)	W-PFCLMS03	0.30	ng/L	**----**	----	<1.20	----	<1.20	----
Perfluorododecane sulfonic acid (PFDoDS)	W-PFCLMS03	0.30	ng/L	**----**	----	<1.20	----	<1.20	----
6:2 Fluorotelomer sulfonic acid (6:2 FTS)	W-PFCLMS03	0.30	ng/L	**----**	----	**1.33**	± 40.0%	<1.20	----
Perfluoroundecane sulfonic acid (PFUnDS)	W-PFCLMS02	10	ng/L	<10	----	**----**	----	**----**	----
Perfluorooctane sulfonamide (FOSA)	W-PFCLMS03	0.30	ng/L	**----**	----	<1.20	----	<1.20	----
Perfluorotridecane sulfonic acid (PFTrDS)	W-PFCLMS02	20	ng/L	<20	----	**----**	----	**----**	----
Perfluorobutanoic acid (PFBA)	W-PFCLMS02	10	ng/L	<120	----	**----**	----	**----**	----
Perfluoropentanoic acid (PFPeA)	W-PFCLMS02	10	ng/L	<10	----	**----**	----	**----**	----
Perfluorohexanoic acid (PFHxA)	W-PFCLMS02	10	ng/L	<10	----	**----**	----	**----**	----
Perfluoroheptanoic acid (PFHpA)	W-PFCLMS02	10	ng/L	<10	----	**----**	----	**----**	----
Perfluorooctanoic acid (PFOA)	W-PFCLMS02	5.0	ng/L	<5.0	----	**----**	----	**----**	----
Perfluorononanoic acid (PFNA)	W-PFCLMS02	10	ng/L	**15**	± 30.0%	**----**	----	**----**	----
Perfluorodecanoic acid (PFDA)	W-PFCLMS02	10	ng/L	<10	----	**----**	----	**----**	----
Perfluoroundecanoic acid (PFUnDA)	W-PFCLMS02	10	ng/L	<10	----	**----**	----	**----**	----
Perfluorododecanoic acid (PFDoDA)	W-PFCLMS02	10	ng/L	<10	----	**----**	----	**----**	----
Perfluorotridecanoic acid (PFTrDA)	W-PFCLMS02	10	ng/L	<10	----	**----**	----	**----**	----
Perfluorobutane sulfonic acid (PFBS)	W-PFCLMS02	10	ng/L	**233**	± 30.0%	**----**	----	**----**	----
Perfluoropentane sulfonic acid (PFPeS)	W-PFCLMS02	10	ng/L	<10	----	**----**	----	**----**	----
Perfluorohexane sulfonic acid (PFHxS)	W-PFCLMS02	10	ng/L	<10	----	**----**	----	**----**	----
Perfluoroheptane sulfonic acid (PFHpS)	W-PFCLMS02	10	ng/L	<10	----	**----**	----	**----**	----
Perfluorooctane sulfonic acid (PFOS)	W-PFCLMS02	5.0	ng/L	<5.0	----	**----**	----	**----**	----
Perfluorononane sulfonic acid (PFNS)	W-PFCLMS02	10	ng/L	<10	----	**----**	----	**----**	----
Perfluorodecane sulfonic acid (PFDS)	W-PFCLMS02	10	ng/L	<10	----	**----**	----	**----**	----
Perfluorododecane sulfonic acid (PFDoDS)	W-PFCLMS02	10	ng/L	<10	----	**----**	----	**----**	----
6:2 Fluorotelomer sulfonic acid (6:2 FTS)	W-PFCLMS02	10	ng/L	<10	----	**----**	----	**----**	----
Perfluorooctane sulfonamide (FOSA)	W-PFCLMS02	10	ng/L	<10	----	**----**	----	**----**	----
Sum of 22 PFAS (M1)	W-PFCLMS02	110	ng/L	**250**	± 40.0%	**----**	----	**----**	----
Sum of 22 PFAS (M1)	W-PFCLMS03	4.85	ng/L	**----**	----	**95.5**	± 40.0%	**88.1**	± 40.0%
Perfluoroundecane sulfonic acid (PFUnDS)	W-PFCLMS03	1.0	ng/L	**----**	----	<4.0	----	<4.0	----
Perfluorotridecane sulfonic acid (PFTrDS)	W-PFCLMS03	1.0	ng/L	**----**	----	<4.0	----	<4.0	----
Physical Parameters									
Electrical Conductivity @ 25°C	W-CON-PCT	0.10	mS/m	**3.37**	± 10.0%	**2.16**	± 10.0%	**5.61**	± 10.0%
pH Value	W-PH-PCT	1.00	-	**6.32**	± 1.3%	**6.23**	± 1.3%	**5.77**	± 1.4%

Sub-Matrix: **WATER**

Client sample ID	L-5-2	L-6-2	F/F-1-2
Laboratory sample ID	PR2263014013	PR2263014014	PR2263014015

Sub-Matrix: **WATER**

				Client sample ID	L-5-2		L-6-2		F/F-1-2	
				Laboratory sample ID	PR2263014013		PR2263014014		PR2263014015	
				Client sampling date / time	15-Jun-2022		22-Jun-2022		19-May-2022	
Parameter	*Method*	*LOR*	*Unit*		**Result**	**MU**	**Result**	**MU**	**Result**	**MU**
Perfluorinated Compounds										
Perfluorobutanoic acid (PFBA)	W-PFCLMS03	2.0	ng/L		<8.0	----	<8.0	----	<8.0	----
Perfluoropentanoic acid (PFPeA)	W-PFCLMS03	0.30	ng/L		<1.20	----	<1.20	----	<1.20	----
Perfluorohexanoic acid (PFHxA)	W-PFCLMS03	0.30	ng/L		<2.40	----	<1.20	----	**2.30**	± 40.0%
Perfluoroheptanoic acid (PFHpA)	W-PFCLMS03	0.30	ng/L		<1.20	----	<1.20	----	**3.35**	± 40.0%
Perfluorooctanoic acid (PFOA)	W-PFCLMS03	0.30	ng/L		<1.20	----	**2.25**	± 40.0%	**22.3**	± 40.0%
Perfluorononanoic acid (PFNA)	W-PFCLMS03	0.30	ng/L		**6.52**	± 40.0%	**17.6**	± 40.0%	<1.20	----
Perfluorodecanoic acid (PFDA)	W-PFCLMS03	0.30	ng/L		<1.20	----	<1.20	----	**1.90**	± 40.0%
Perfluoroundecanoic acid (PFUnDA)	W-PFCLMS03	0.30	ng/L		<1.20	----	**8.87**	± 40.0%	<1.20	----
Perfluorododecanoic acid (PFDoDA)	W-PFCLMS03	0.30	ng/L		<1.20	----	<1.20	----	**1.35**	± 40.0%
Perfluorotridecanoic acid (PFTrDA)	W-PFCLMS03	0.30	ng/L		<1.20	----	<1.20	----	<1.20	----
Sum of 4 PFAS (M1)	W-PFCLMS03	0.60	ng/L		**8.94**	± 40.0%	**49.6**	± 40.0%	**81.4**	± 40.0%
Perfluorobutane sulfonic acid (PFBS)	W-PFCLMS03	0.30	ng/L		**32.1**	± 40.0%	**13.2**	± 40.0%	<4.80	----
Perfluoropentane sulfonic acid (PFPeS)	W-PFCLMS03	0.30	ng/L		<1.20	----	<1.20	----	<1.20	----
Perfluorohexane sulfonic acid (PFHxS)	W-PFCLMS03	0.30	ng/L		<1.20	----	<1.20	----	**1.36**	± 40.0%
Perfluoroheptane sulfonic acid (PFHpS)	W-PFCLMS03	0.30	ng/L		<1.20	----	<1.20	----	<1.20	----
Perfluorooctane sulfonic acid (PFOS)	W-PFCLMS03	0.30	ng/L		**2.42**	± 40.0%	**29.8**	± 40.0%	**57.7**	± 40.0%
Perfluorononane sulfonic acid (PFNS)	W-PFCLMS03	0.30	ng/L		<1.20	----	<1.20	----	<1.20	----
Perfluorodecane sulfonic acid (PFDS)	W-PFCLMS03	0.30	ng/L		<1.20	----	<1.20	----	<1.20	----
Perfluorododecane sulfonic acid (PFDoDS)	W-PFCLMS03	0.30	ng/L		<1.20	----	<1.20	----	<1.20	----
6:2 Fluorotelomer sulfonic acid (6:2 FTS)	W-PFCLMS03	0.30	ng/L		<1.20	----	<1.20	----	<1.20	----
Perfluorooctane sulfonamide (FOSA)	W-PFCLMS03	0.30	ng/L		<1.20	----	<1.20	----	<1.20	----
Sum of 22 PFAS (M1)	W-PFCLMS03	4.85	ng/L		**41.0**	± 40.0%	**71.7**	± 40.0%	**90.3**	± 40.0%
Perfluoroundecane sulfonic acid (PFUnDS)	W-PFCLMS03	1.0	ng/L		<4.0	----	<4.0	----	<4.0	----
Perfluorotridecane sulfonic acid (PFTrDS)	W-PFCLMS03	1.0	ng/L		<4.0	----	<4.0	----	<4.0	----
Physical Parameters										
Electrical Conductivity @ 25°C	W-CON-PCT	0.10	mS/m		**2.17**	± 10.0%	**1.96**	± 10.0%	**5.21**	± 10.0%
pH Value	W-PH-PCT	1.00	-		**6.07**	± 1.3%	**6.42**	± 1.2%	**6.35**	± 1.2%

Sub-Matrix: **WATER**

				Client sample ID	F/F-2-2		F/F-3-2		F/F-4-2	
				Laboratory sample ID	PR2263014016		PR2263014017		PR2263014018	
				Client sampling date / time	25-May-2022		01-Jun-2022		08-Jun-2022	
Parameter	*Method*	*LOR*	*Unit*		**Result**	**MU**	**Result**	**MU**	**Result**	**MU**
Perfluorinated Compounds										
Perfluorobutanoic acid (PFBA)	W-PFCLMS03	2.0	ng/L		<16.0	----	**----**	----	**----**	----
Perfluorobutanoic acid (PFBA)	W-PFCLMS03	2.0	ng/L		**----**	----	<60.0	----	<20.0	----
Perfluoropentanoic acid (PFPeA)	W-PFCLMS03	0.30	ng/L		<31.2	----	**----**	----	**----**	----
Perfluoropentanoic acid (PFPeA)	W-PFCLMS03	0.30	ng/L		**----**	----	<18.0	----	<18.0	----
Perfluorohexanoic acid (PFHxA)	W-PFCLMS03	0.30	ng/L		<4.80	----	**----**	----	**----**	----
Perfluorohexanoic acid (PFHxA)	W-PFCLMS03	0.30	ng/L		**----**	----	<90.0	----	<90.0	----
Perfluoroheptanoic acid (PFHpA)	W-PFCLMS03	0.30	ng/L		**4.84**	± 40.0%	**----**	----	**----**	----
Perfluoroheptanoic acid (PFHpA)	W-PFCLMS03	0.30	ng/L		**----**	----	<9.00	----	<9.00	----
Perfluorooctanoic acid (PFOA)	W-PFCLMS03	0.30	ng/L		**27.3**	± 40.0%	**----**	----	**----**	----

Sub-Matrix: **WATER**

Parameter	Method	LOR	Unit	Client sample ID		F/F-2-2		F/F-3-2		F/F-4-2	
				Laboratory sample ID		PR2263014016		PR2263014017		PR2263014018	
				Client sampling date / time		25-May-2022		01-Jun-2022		08-Jun-2022	
						Result	MU	Result	MU	Result	MU
Perfluorinated Compounds - Continued											
Perfluorooctanoic acid (PFOA)	W-PFCLMS03	0.30	ng/L			----	----	**5.87**	± 40.0%	**2.02**	± 40.0%
Perfluorononanoic acid (PFNA)	W-PFCLMS03	0.30	ng/L			<1.20	----	----	----	----	----
Perfluorononanoic acid (PFNA)	W-PFCLMS03	0.30	ng/L			----	----	**0.58**	± 40.0%	**0.45**	± 40.0%
Perfluorodecanoic acid (PFDA)	W-PFCLMS03	0.30	ng/L			**1.22**	± 40.0%	----	----	----	----
Perfluorodecanoic acid (PFDA)	W-PFCLMS03	0.30	ng/L			----	----	**0.80**	± 40.0%	**0.42**	± 40.0%
Perfluoroundecanoic acid (PFUnDA)	W-PFCLMS03	0.30	ng/L			<1.20	----	----	----	----	----
Perfluoroundecanoic acid (PFUnDA)	W-PFCLMS03	0.30	ng/L			----	----	<0.30	----	**0.33**	± 40.0%
Perfluorododecanoic acid (PFDoDA)	W-PFCLMS03	0.30	ng/L			<1.20	----	----	----	----	----
Perfluorododecanoic acid (PFDoDA)	W-PFCLMS03	0.30	ng/L			----	----	<0.30	----	<0.30	----
Perfluorotridecanoic acid (PFTrDA)	W-PFCLMS03	0.30	ng/L			<1.20	----	----	----	----	----
Perfluorotridecanoic acid (PFTrDA)	W-PFCLMS03	0.30	ng/L			----	----	<0.30	----	<0.30	----
Sum of 4 PFAS (M1)	W-PFCLMS03	0.60	ng/L			**62.2**	± 40.0%	**37.4**	± 40.0%	**15.0**	± 40.0%
Perfluorobutane sulfonic acid (PFBS)	W-PFCLMS03	0.30	ng/L			<4.80	----	----	----	----	----
Perfluorobutane sulfonic acid (PFBS)	W-PFCLMS03	0.30	ng/L			----	----	<6.00	----	<15.0	----
Perfluoropentane sulfonic acid (PFPeS)	W-PFCLMS03	0.30	ng/L			<1.20	----	----	----	----	----
Perfluoropentane sulfonic acid (PFPeS)	W-PFCLMS03	0.30	ng/L			----	----	<0.30	----	<0.30	----
Perfluorohexane sulfonic acid (PFHxS)	W-PFCLMS03	0.30	ng/L			<1.20	----	----	----	----	----
Perfluorohexane sulfonic acid (PFHxS)	W-PFCLMS03	0.30	ng/L			----	----	**0.72**	± 40.0%	<0.30	----
Perfluoroheptane sulfonic acid (PFHpS)	W-PFCLMS03	0.30	ng/L			<1.20	----	----	----	----	----
Perfluoroheptane sulfonic acid (PFHpS)	W-PFCLMS03	0.30	ng/L			----	----	<0.30	----	<0.30	----
Perfluorooctane sulfonic acid (PFOS)	W-PFCLMS03	0.30	ng/L			**34.9**	± 40.0%	----	----	----	----
Perfluorooctane sulfonic acid (PFOS)	W-PFCLMS03	0.30	ng/L			----	----	**30.2**	± 40.0%	**12.5**	± 40.0%
Perfluorononane sulfonic acid (PFNS)	W-PFCLMS03	0.30	ng/L			<1.20	----	----	----	----	----
Perfluorononane sulfonic acid (PFNS)	W-PFCLMS03	0.30	ng/L			----	----	<0.30	----	<0.30	----
Perfluorodecane sulfonic acid (PFDS)	W-PFCLMS03	0.30	ng/L			<1.20	----	----	----	----	----
Perfluorodecane sulfonic acid (PFDS)	W-PFCLMS03	0.30	ng/L			----	----	<0.30	----	<0.30	----
Perfluorododecane sulfonic acid (PFDoDS)	W-PFCLMS03	0.30	ng/L			<1.20	----	----	----	----	----
Perfluorododecane sulfonic acid (PFDoDS)	W-PFCLMS03	0.30	ng/L			----	----	<0.30	----	<0.30	----
6:2 Fluorotelomer sulfonic acid (6:2 FTS)	W-PFCLMS03	0.30	ng/L			<1.20	----	----	----	----	----
6:2 Fluorotelomer sulfonic acid (6:2 FTS)	W-PFCLMS03	0.30	ng/L			----	----	**0.38**	± 40.0%	<0.30	----
Perfluorooctane sulfonamide (FOSA)	W-PFCLMS03	0.30	ng/L			<1.20	----	----	----	----	----
Perfluorooctane sulfonamide (FOSA)	W-PFCLMS03	0.30	ng/L			----	----	<0.30	----	<0.30	----
Sum of 22 PFAS (M1)	W-PFCLMS03	4.85	ng/L			**68.3**	± 40.0%	**38.6**	± 40.0%	**15.7**	± 40.0%

Sub-Matrix: **WATER**

				Client sample ID	F/F-2-2		F/F-3-2		F/F-4-2	
				Laboratory sample ID	PR2263014016		PR2263014017		PR2263014018	
				Client sampling date / time	25-May-2022		01-Jun-2022		08-Jun-2022	
Parameter	*Method*	*LOR*	*Unit*		**Result**	**MU**	**Result**	**MU**	**Result**	**MU**
Perfluorinated Compounds - Continued										
Perfluoroundecane sulfonic acid (PFUnDS)	W-PFCLMS03	1.0	ng/L		<4.0	----	**----**	----	**----**	----
Perfluoroundecane sulfonic acid (PFUnDS)	W-PFCLMS03	1.0	ng/L		**----**	----	<1.0	----	<1.0	----
Perfluorotridecane sulfonic acid (PFTrDS)	W-PFCLMS03	1.0	ng/L		<4.0	----	**----**	----	**----**	----
Perfluorotridecane sulfonic acid (PFTrDS)	W-PFCLMS03	1.0	ng/L		**----**	----	<1.0	----	<1.0	----
Physical Parameters										
Electrical Conductivity @ 25°C	W-CON-PCT	0.10	mS/m		**4.76**	± 10.0%	**3.81**	± 10.0%	**2.68**	± 10.0%
pH Value	W-PH-PCT	1.00	-		**6.32**	± 1.3%	**6.12**	± 1.3%	**5.94**	± 1.3%

Sub-Matrix: **WATER**

				Client sample ID	F/F-5-2		F/F-6-2		**----**	
				Laboratory sample ID	PR2263014019		PR2263014020		----	
				Client sampling date / time	15-Jun-2022		22-Jun-2022		----	
Parameter	*Method*	*LOR*	*Unit*		**Result**	**MU**	**Result**	**MU**	**Result**	**MU**
Perfluorinated Compounds										
Perfluorobutanoic acid (PFBA)	W-PFCLMS03	2.0	ng/L		<60.0	----	<24.0	----	**----**	----
Perfluoropentanoic acid (PFPeA)	W-PFCLMS03	0.30	ng/L		<18.0	----	<60.0	----	**----**	----
Perfluorohexanoic acid (PFHxA)	W-PFCLMS03	0.30	ng/L		<90.0	----	<96.0	----	**----**	----
Perfluoroheptanoic acid (PFHpA)	W-PFCLMS03	0.30	ng/L		<9.00	----	<9.60	----	**----**	----
Perfluorooctanoic acid (PFOA)	W-PFCLMS03	0.30	ng/L		**3.57**	± 40.0%	**2.80**	± 40.0%	**----**	----
Perfluorononanoic acid (PFNA)	W-PFCLMS03	0.30	ng/L		<0.30	----	<1.20	----	**----**	----
Perfluorodecanoic acid (PFDA)	W-PFCLMS03	0.30	ng/L		**0.37**	± 40.0%	<1.20	----	**----**	----
Perfluoroundecanoic acid (PFUnDA)	W-PFCLMS03	0.30	ng/L		<0.30	----	<1.20	----	**----**	----
Perfluorododecanoic acid (PFDoDA)	W-PFCLMS03	0.30	ng/L		<0.30	----	<1.20	----	**----**	----
Perfluorotridecanoic acid (PFTrDA)	W-PFCLMS03	0.30	ng/L		<0.30	----	<1.20	----	**----**	----
Sum of 4 PFAS (M1)	W-PFCLMS03	0.60	ng/L		**17.6**	± 40.0%	**43.8**	± 40.0%	**----**	----
Perfluorobutane sulfonic acid (PFBS)	W-PFCLMS03	0.30	ng/L		<9.00	----	<24.0	----	**----**	----
Perfluoropentane sulfonic acid (PFPeS)	W-PFCLMS03	0.30	ng/L		<0.30	----	<1.20	----	**----**	----
Perfluorohexane sulfonic acid (PFHxS)	W-PFCLMS03	0.30	ng/L		<0.30	----	<1.20	----	**----**	----
Perfluoroheptane sulfonic acid (PFHpS)	W-PFCLMS03	0.30	ng/L		<0.30	----	<1.20	----	**----**	----
Perfluorooctane sulfonic acid (PFOS)	W-PFCLMS03	0.30	ng/L		**14.0**	± 40.0%	**41.0**	± 40.0%	**----**	----
Perfluorononane sulfonic acid (PFNS)	W-PFCLMS03	0.30	ng/L		<0.30	----	<1.20	----	**----**	----
Perfluorodecane sulfonic acid (PFDS)	W-PFCLMS03	0.30	ng/L		<0.30	----	<1.20	----	**----**	----
Perfluorododecane sulfonic acid (PFDoDS)	W-PFCLMS03	0.30	ng/L		<0.30	----	<1.20	----	**----**	----
6:2 Fluorotelomer sulfonic acid (6:2 FTS)	W-PFCLMS03	0.30	ng/L		<0.30	----	<1.20	----	**----**	----
Perfluorooctane sulfonamide (FOSA)	W-PFCLMS03	0.30	ng/L		**0.38**	± 40.0%	<1.20	----	**----**	----
Sum of 22 PFAS (M1)	W-PFCLMS03	4.85	ng/L		**18.3**	± 40.0%	**43.8**	± 40.0%	**----**	----
Perfluoroundecane sulfonic acid (PFUnDS)	W-PFCLMS03	1.0	ng/L		<1.0	----	<4.0	----	**----**	----
Perfluorotridecane sulfonic acid (PFTrDS)	W-PFCLMS03	1.0	ng/L		<1.0	----	<4.0	----	**----**	----
Physical Parameters										

Sub-Matrix: **WATER**				Client sample ID	F/F-5-2		F/F-6-2		----	
				Laboratory sample ID	PR2263014019		PR2263014020		----	
				Client sampling date / time	15-Jun-2022		22-Jun-2022		----	
Parameter	*Method*	*LOR*	*Unit*	**Result**	**MU**		**Result**	**MU**	**Result**	**MU**
Physical Parameters - Continued										
Electrical Conductivity @ 25°C	W-CON-PCT	0.10	mS/m	**5.89**	± 10.0%		**2.87**	± 10.0%	**----**	----
pH Value	W-PH-PCT	1.00	-	**6.42**	± 1.2%		**6.45**	± 1.2%	**----**	----

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes. Measurement uncertainty is expressed as expanded measurement uncertainty with coverage factor k = 2, representing 95% confidence level.
Key: LOR = Limit of reporting; MU = Measurement Uncertainty. The MU does not include sampling uncertainty.

The end of result part of the certificate of analysis

Brief Method Summaries

Analytical Methods	*Method Descriptions*
Location of test performance: Na Harfe 336/9 Prague 9 - Vysocany Czech Republic 190 00	
W-CON-PCT	CZ_SOP_D06_02_075 (ČSN EN 27 888, SM 2520 B) Determination of electrical conductivity by conductometer and calculation of salinity.
W-PFCLMS02	CZ_SOP_D06_03_197.A (US EPA 537, CSN P CEN/TS 15968) Determination of perfluorinated and brominated compounds by liquid chromatography with MS/MS detection.
W-PFCLMS03	CZ_SOP_D06_03_197.A (US EPA 537, CSN P CEN/TS 15968) Determination of perfluorinated and brominated compounds by liquid chromatography with MS/MS detection.
W-PH-PCT	CZ_SOP_D06_02_105 (CSN ISO 10523, US EPA 150.1, SM 4500-H+ B) Determination of pH by potentiometry

Preparation Methods	*Method Descriptions*
Location of test performance: Na Harfe 336/9 Prague 9 - Vysocany Czech Republic 190 00	
* W-LTS3	Storage sample three months since receiving date.

A "*" symbol preceding any method indicates laboratory or subcontractor non-accredited test. If the UNICO-SUB code is stated in the method table, this only informs that the tests have been performed by a subcontractor and the results are given in an annex to the test report, including information on test accreditation. In the case when a procedure specified in an accredited method was used for non-accredited matrix, the reported results are non-accredited; please refer to information in General Comment section on the front page. If the report contains subcontracted analyses, those are made in a subcontracted laboratory outside the laboratories ALS Czech Republic, s.r.o.
The calculation methods of summation parameters are available on request in the client service.

Leaching of problematic substances during storage of WEEE
This report describes the performance and results of leaching tests on three different types of WEEE (Waste Electrical and Electronic Equipment).The aim of the leaching tests was to provide insight into the leaching and potential environmental impacts of met-als, metalloids, salts, dissolved organic carbon, polychlorinated biphenyls, phthalates, organotin compounds and brominated flame retardants (with special focus on “novel” brominated flame retardants) during temporary outdoor storage scenarios.

Projektet har til formål at øge vores viden om udvaskning af problematiske stoffer fra elektronikaffald. Konkret har projektet i en udført udvaskningsforsøg med en række konkrete elektronikprodukter som har stået midlertidigt udækket og målt på udledning herfra.

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