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Screening Programme 2020, Part 1 and 2:

Plastic Additives and REACH Compounds

Photo: Peter van Beusekom, NIVA & Martin Schlabach, NILU

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REPORT

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Summary

I screening 2020 gjennomført av Norsk institutt for vannforskning (NIVA) og NILU-Norsk institutt for luftforskning i fellesskap ble det satt søkelys på forekomst og mulige miljøproblemer av 160 kjemikalier. Forbindelser som er valgt ut til Screening 2020 inkluderer tilsetningsstoffer til plast og nylig registrerte stoffer i REACH registeret.

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Screening Programme 2020, Part 1 and 2:

Plastic Additives and REACH Compounds

Preface

On behalf of the Norwegian Environment Agency (Miljødirektoratet) the Norwegian Institute for Water Research (NIVA) in collaboration with NILU – Norwegian Institute for Air Research have carried out the 2020 screening programme part 1 and 2: plastic additives and REACH compounds.

Sampling was carried out by Pernilla Bohlin-Nizzetto, Heidi Eikenes (NILU), Christian Vogelsang, Elisabeth Rødland and Bjørnar Beylich (NIVA). Chemical analyses were performed by Vladimir Nikiforov, Michael Harju, Pawel Rostkowski, Norbert Schmidbauer (NILU), Thomas Rundberget, Jose Antonio Baz Lomba and Alfhild Kringstad (NIVA).

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Oslo, 23.10.2021

Bert van Bavel
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Summary

The screening project 2020 conducted by the Norwegian Institute for Water Research (NIVA) and NILU-Norwegian Institute for Air Research has focused on the occurrence and potential environmental risk of 160 chemicals. The compounds were selected based on possible use as plastic additives and newly registered REACH compounds.

Most of these compounds cannot be assigned to a single emission source as they are widely used in different technical products, cosmetics, and medicines. Sampling sites and sample-types should therefore reflect a broad mix of potential sources. In this regard, a set of sample matrices from the area around the Alna valley (Oslo East) were selected. This is an area with dense population and is home to a variety of industries, trade, and transport. Samples were collected from indoor environments (residential and non-residential), surface waters, sludge, and effluent from a sewage treatment plant (WWTP). Potential hotspots for the targeted chemicals included tunnel wash run-off, vehicle wash facilities, cars, and artificial turf/rubber flooring. Finally, the receiving marine environment was included by collection of samples from sediment and biota. In total, 160 compounds were analysed in one or more of the 22 different sample types. There were more than 200 individual samples collected from more than 30 locations, all analysed using 10 different sample pre-treatments, clean up and analytical methods.

Fifty percent of the targeted compounds in this project were detected in at least one of the sample types, but many compounds were not detectable in the samples. Several compounds were found in comparatively high concentrations in some sample types. However, the assessment of the relevance of these results is hampered by lack of available information on the potential environmental effects of many of these compounds. It is advisable to prioritize additional sampling and analysis of the detected compounds to confirm their occurrence and concentrations in a broader context.

Road tunnel wash, car wash facilities and artificial turf run off water are good indicators for emissions to the aquatic environment and several of the targeted compounds of the screening 2020 project were detected in these sample types.

Both indoor samples and WWTP samples are good indicators for the implementation and usage of chemicals in our society. These sample types often contain relatively high or high enough concentrations to detect emerging compounds. The indoor air and dust samples collected at different locations in this study give a good overview of currently used and emitted volatile and semi volatile compounds.

In recipients such as surface water and biological samples it is often more difficult to detect emerging compounds. The reason for this is dual. Firstly, the concentrations in these matrices are low as a result of dilution in the environment. Secondly, broad analytical screening methods targeting a wide array of chemicals in complex biological matrices suffer from poorer detection limits (LoD).

Some examples of notable detections include the presence of 1,1,1,3,5,5,5-heptamethyl-3-[(trimethylsilyl)oxy] trisiloxane (M3T) in surface water samples from the Alna river, although the concentration is currently still below the PNEC (NORMAN 2021). The sources for M3T to surface water are not found in this study as M3T was rarely detected in other matrices; only at one public site (a kindergarten), one residential site and one car after being washed. Of the semi volatile organic compounds, triallyl cyanurate and triallyl isocyanurate were found at high levels in road tunnel wash, but surprisingly at similar levels in surface water at several locations from the Alna river. The maximum levels measured were close to the PNEC value reported for aquatic organisms (NORMAN, 2021). Dechlorane 602 and 603 were found in biological samples (Fish liver) and (Herring gull egg) in addition to Dechlorane plus (syn and anti) which were also found in several of the dust samples and car (wash) wipes.

Nearly all compounds from the plasticiser group were found in dust or wipe samples from different locations. 2,2-bis(chloromethyl)-1,3-propanediyl tetrakis (2-chloroethyl) ester (IDDPP) was also found in surface water, but di-iso-nonyl phthalate (DiNP) and di-iso-decyl phthalate (DIDP) might be of more concern as the detected levels were very high and exceeding the reported PNEC (NORMAN 2021).

In WWTP-effluent and sludge, the UV sunscreen Iscotrizinol and the laundry detergent optical brighteners Tinopal were found in moderate levels. N-(1,3-dimethylbutyl)-N'-phenyl-p-phenylenediamine quinone (6PPD-Q), a degradation product of 6PPD used as an additive in car tires, was found in high concentrations in road tunnel wash water, soil/sediment from the marina, WWTP-effluent and sludge, car wash wipes and artificial turf and dust. This compound is associated with adult Coho salmon mortality in two recent publications and low levels were found in one of the Alna river samples.

Several benzothiazoles were detected in road wash water, but also artificial turf granulates contained a wide variety of this compound class including 2-(methylthio) benzothiazole, N-tert-butyl-2-benzo¬thiazole¬sulfenamide, N-cclohexyl-2-benzothiazolesulfenamide, 2-mercaptobenzothiazole. The concentration of other benzothiazoles including 2-aminobenzothiazole, 2-benzothiazolinone and 2-Benzothiazolesulfonic acid were only slightly lower that reported freshwater PNEC values (NORMAN 2021).

The surfactants N,N-dimethyldodecan-1-amine, N,N-dimethyl-1-hexadecanamine, N,N-dimethyl-1-tetradecanamine were all found in WWTP-effluents. Highest concentrations were found for N,N-dimethyldodecylamine-N-oxide in car wash and non-residential indoor environments.

During the analysis of the water samples from Breivoll and to a lesser account from Kværner, several well-known volatile halogenated compounds were detected including trichloromethane, dichloromethane, trichloroethene, tetrachloroethene, dichloroethane, tetrachloromethane and dichlorobromomethane. The levels of trichloromethane and dichlorobromomethane were exceeding the lowest PNEC for the freshwater environment (NORMAN 2021).

Sammendrag

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I screening 2020 gjennomført av Norsk institutt for vannforskning (NIVA) og NILU-Norsk institutt for luftforskning i fellesskap ble det satt søkelys på forekomst og mulige miljøproblemer av 160 kjemikalier. Forbindelser som er valgt ut til Screening 2020 inkluderer tilsetningsstoffer til plast og nylig registrerte stoffer i REACH registeret.

De fleste av disse forbindelsene kan ikke tilordnes en enkelt utslippskilde da de er brukt i mange forskjellige tekniske produkter, men også kosmetikk og medisin. Prøvetakingslokaliteter og prøvetyper bør derfor reflektere mange mulige kilder. Det ble derfor valgt å undersøke området Alnadalen (Oslo øst) som er et område med tett befolkning og en rekke næringer, handel og transport. Prøver ble samlet inn fra innendørsmiljøer (bolig og kontor/forretningsbygg), overflatevann, slam og avløp fra kloakkrenseanlegg, hotspots som avrenning fra tunnelvask, bil/storbil-vask og kunstgressbaner, og til slutt marine resipienter (sediment og biota). Totalt ble 160 forbindelser analysert i en eller flere av de 22 forskjellige prøvetypene, som bestod av mer enn 200 forskjellige individuelle prøver fra mer enn 30 forskjellige steder, og der det ble brukt 10 ulike analysemetoder.

Femti prosent av de prioriterte forbindelsene i studien ble funnet i minst én av prøvetypene som ble valgt, men mange forbindelser ble ikke funnet over deteksjonsgrensen. Noen forbindelser ble funnet i relativt høye konsentrasjoner i enkelte prøver, men for mange av disse forbindelsene finnes det lite eller ingen informasjon om miljøeffekter, og betydning av resultatene er derfor vanskelig å vurdere. Noen av disse forbindelsene gir høyst sannsynlig lav miljørisiko og prioriteres ikke for en umiddelbar oppfølging. Imidlertid ble flere forbindelser funnet i relativt høye konsentrasjoner i flere prøvetyper. Disse bør undersøkes nærmere ved å bekrefte forekomsten og konsentrasjonene i et større antall prøver og å se nærmere på miljø- og helserisikoen ved disse forbindelsene.

Tunnelvask, bilvaskeanlegg og rensevann/smeltevann fra kunstgressbaner gir en pekepinn for utslipp til vannmiljøet. Prøver fra disse matriser resulterte i identifisering og kvantifisering av flere stoffer i dette prosjektet.

Luft- og støvprøver fra forskjellige typer innemiljø sammen med prøver fra renseanlegg gir en god oversikt over forekomst og spredning av kjemiske forbindelser som brukes i dag. Både innemiljøprøver og vann/slam fra renseanlegg er gode indikatorer for aktuell bruk samt innfasing av nye. Disse prøvetypene inneholder ofte relativt høye eller høye nok konsentrasjoner til å oppdage nye forbindelser.

I resipienter som overflatevann og spesielt i biologiske prøver er det noe vanskeligere å oppdage nye forbindelser på grunn av en kombinasjon av fortynningen av disse forbindelsene i miljøet og vanskeligheter med å oppnå lave nok deteksjonsgrenser for biologiske prøver i en slik innledende studie.

Et slikt relevant funn er forekomst av 1,1,1,3,5,5,5-heptametyl-3-[(trimetylsilyl)oksy]trisiloksan (M3T) i overflatevannsprøver fra Alnaelva, selv om konsentrasjonen for øyeblikket fortsatt er under PNEC (NORMAN 2021). I andre matriser ble M3T kun detektert i noen få prøver; en offentlig bygg (barnehage), en bolig og en bil etter vask. På grunn av dette er det vanskelig å diskutere kilder for M3T i overflatevann. Av de semi-flyktige organiske forbindelsene ble triallylcyanurat (TAC) og triallylisocyanurat (isoTAC) funnet i høye nivåer i veitunnelvask, men overraskende nok på tilsvarende nivåer i overflatevann flere steder fra Alnaelva. Maksimumsnivåene som ble målt var nær PNEC-verdien rapportert for vannlevende organismer (NORMAN, 2021). Dechlorane 602 og 603 ble funnet i biologiske prøver (fiskelever) og (sildemåseegg). Videre ble Dechlorane plus (syn og anti) også funnet i flere av støvprøvene og klutprøver tatt inne i biler som viser at disse organiske forurensningene er potensielt til stede i miljøet.

Nesten alle forbindelser fra mykgjørere gruppe ble funnet i støv- eller klutprøver fra forskjellige steder, 2,2-bis(klormetyl)-1,3-propandiyltetrakis(2-kloretyl)ester (IDDPP) ble også funnet i overflatevann, men di-iso-nonylftalat (DiNP) og di-iso-decylftalat (DiDP) kan være mer bekymringsfulle ettersom nivåene var svært høye og oversteg den rapporterte ferskvanns PNEC (NORMAN 2021).

I avløp og slam fra renseanlegg ble solkremkompontent Iscotrizinol og det optiske hvitemiddel Tinopal funnet i moderate nivåer. N-(1,3-dimetylbutyl)-N'-fenyl-p-fenylendiaminkinon (6PPD-Q) et nedbrytningsprodukt av 6PPD brukt som tilsetning til bildekk og andre gummiprodukter ble funnet i høye konsentrasjoner i veitunnel vaskevann, jord/sediment i veitunneler fra marinaen, avløp og slam fra renseanlegg og kunstgressgranulat. Denne forbindelsen er knyttes direkte til akutt dødelighet av voksen laks som vist i to nyere publikasjoner. Lave nivåer ble funnet i en av prøvene i Alnaelva.

Flere benzotiazoler ble funnet i tunnelvaskevann, men også kunstgressgranulater inneholdt et bredt utvalg av denne forbindelsesklassen, inkludert 2-(Methylthio)benzotiazol, N-tert-Butyl-2-benzotiazolsulfenamid, N-Cyclohexyl-2-benzotiazolsulfenamid, 2-merkaptobenzotiazol. Konsentrasjonen av andre benzotiazoler inkludert 2-aminobenzotiazol, 2-benzotiazolinon og 2-benzotiazolsulfonsyre var bare litt lavere enn rapporterte ferskvanns PNEC-verdier (NORMAN 2021).

De overflateaktive stoffene N,N-dimetyldodekan-1-amin, N,N-dimetyl-1 heksadekanamin, N,N-dimetyl-1 tetradekanamin ble alle funnet i avløp fra renseanlegg. Høyeste konsentrasjoner ble funnet for N,N-dimetyldodecylamin-N-oksid for bilvask og næringsbygg.

I vannprøvene fra Breivoll, og delvis også fra Kværner, ble det påvist flere kjente flyktige halogenerte forbindelser inkludert triklormetan, diklormetan, trikloreten, tetrakloreten, dikloretan, tetraklormetan og diklorbrometan. Nivåene av triklormetan og diklorbrommetan oversteg den laveste PNEC for ferskvannsmiljøet (NORMAN 2021).

1 Background and introduction

1.1 General

The 2020 Screening Programme of the Norwegian Environment Agency aims at reducing knowledge-gaps in relation to plastic and polymer related chemicals and compounds recently registered in REACH. The compounds selected are mostly related to products with a very general area of use, however, some hotspots may still occur in Norway. There is, however, no information indicating that these compounds are produced in Norway, so hotspots from factory emissions during production are unlikely. Most of the compounds are included as one of several ingredients in various products and materials. These can be plastic, paint, tires and other rubber products, electronics, textiles, household chemicals, as well as other products used in private households, crafts and industry, laundries, leisure boats and more.

When it comes to environmental properties of the compounds, we have two extremes; a large group of chemicals with minimal vapor pressure that are used in solid articles, and another group of volatile and hydrophobic compounds that are mainly used as solvents. Emissions of the latter group of compounds are largely to air. This can be indoor air in (new) homes, public buildings, furniture stores, (new) cars and car-related indoor environments.

For less volatile chemicals found in plastic and rubber articles, the natural choice of sampling locations includes house dust (Schlabach, Halse et al. 2019). Tyre-related products associated with vehicle transport and polymer coatings associated with marine transport are also very relevant. Sampling of water from tunnel washes, vehicle wash facilities and winter storage for leisure boats (marinas) were therefore selected as relevant for these substances.

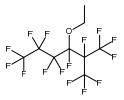
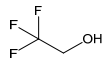
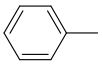
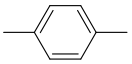
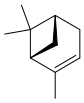
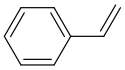
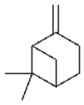
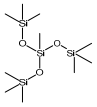
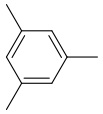
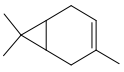
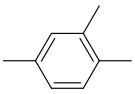
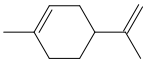
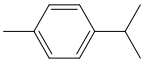
1.2 Selected compounds

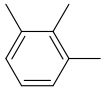
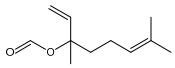
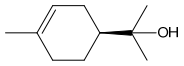
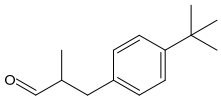
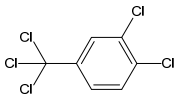
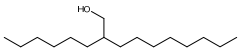
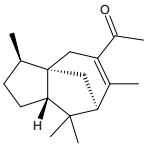
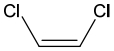
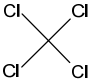
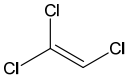
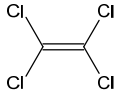
The 2020 Screening programme included an array of chemicals with a varied set of physiochemical properties and fields of application. For intelligent sampling-design and selection of the most cost-effective and accurate analytical methodology, this large set of compounds has been divided into groups. In addition to the original list of compounds, a large set of extra compounds routinely measured were included. Details about the targeted compounds and associated groups are given below.

1.2.1 Volatile organic compounds

A set of volatile organic compounds (VOC) used as solvents, heat transfer fluids, intermediates in chemical production, monomers in polymer production, fragrances, and reaction biproducts were selected for screening in 2020 Table 1.

Table 1: Selected volatile organic compounds (VOC) with their common name, acronyms used in this report, CAS number, chemical structure, priority of the compound (1-3), or extra compound (extra). Priority compounds are written in bold.

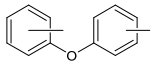
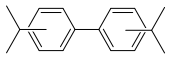
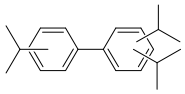
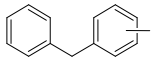
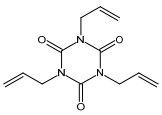
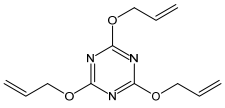
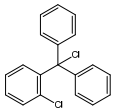
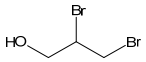
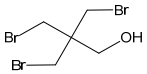
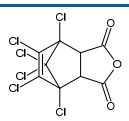
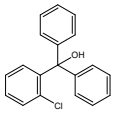
Name	Acronym	CAS	Structure	Group	Priority
3-Ethoxyperfluoro(2-methylhexane)	**HFE-7500**	297730-93-9		VOC	1
2,2,2-Trifluoroethanol	**TFE**	75-89-8		VOC	2
Benzene	Benzene	71-43-2		VOC	extra
Toluene	Toluene	108-88-3		VOC	extra
m+p-Xylene	m+p-Xylene	108-38-3		VOC	extra
o-Xylene	o-Xylene	95-47-6		VOC	extra
(1R)-α-Pinene	**α-Pinene**	80-56-8, 7785-70-8		VOC	1
Styrene	Styrene	100-42-5		VOC	extra
β-Pinene	β-Pinene	127-91-3, 18172-67-3		VOC	extra
1,1,1,3,5,5,5-heptamethyl-3-[(trimethylsilyl)oxy] trisiloxane	**M3T**	17955-88-3		VOC	1
1,3,5-Trimethylbenzene	135-TMBz	108-67-8		VOC	extra
3-Carene	**3-Carene**	13466-78-9		VOC	3
1,2,4-Trimetylbenzene	124-TMBz	95-63-6		VOC	extra
Limonene	Limonene	138-86-3		VOC	extra
p-Cymene	**p-Cymene**	99-87-6		VOC	1

Name	Acronym	CAS	Structure	Group	Priority
1,2,3-Trimethylbenzene	123-TMBz	526-73-8		VOC	extra
Linalyl formate	**Linalyl formate**	115-99-1		VOC	3
(-)-α-Terpineol	**Terpineol**	10482-56-1		VOC	1
2-(4-Tert-Butylbenzyl)propion-aldehyde	**Lilial**	80-54-6		VOC	1
1,2-Dichloro-4-(trichloromethyl)benzene	**DCBTC**	13014-24-9		VOC	1
2-Hexyl-1-decanol	**HxDcOH**	2425-77-6		VOC	3
Acetylcedrene	**AcCedrene**	32388-55-9		VOC	1
Dichloroethene	DCE	156-59-2		VOC	Extra
Dichlormethane	DCM	75-09-2		VOC	Extra
Tetrachloromethane	CCl_4	56-23-5		VOC	Extra
Trichloromethane	TCM	67-66-3		VOC	Extra
Trichloroethene	TCE	79-01-6		VOC	Extra
Bromodichloromethane	BDCM	75-27-4		VOC	Extra
Tetrachloroethene	PCE	127-18-4		VOC	Extra

1.2.2 Semi-volatile organic compounds

A number of semi-volatile organic compounds (SVOC) used as solvents, heat transfer fluids, vulcanisation agent, cross-linking agent, biocide, and flame retardant were selected for screening in 2020 Table 2.

Table 2: Selected semi-volatile organic compounds (SVOC) with common name, acronyms used in this report, CAS number, chemical structure, priority compound (1-3), or extra compound (extra). Priority compounds are written in bold.

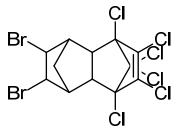
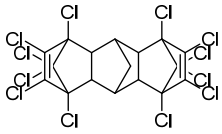
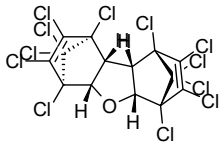
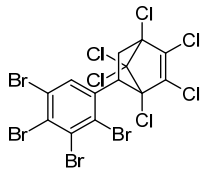
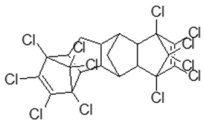
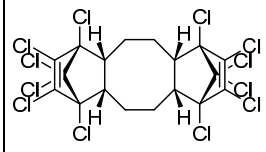
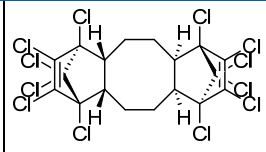
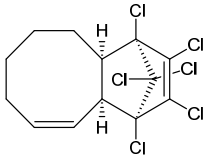
Name	Acronym	CAS	Structure	Group	Priority
Ditolyl ether	**DTE**	28299-41-4		SVOC	1
Bis(1-methylethyl)-1,1'-biphenyl	**DIPBP**	69009-90-1		SVOC	1
Tris(1-methylethyl)-1,1'-biphenyl	**TIPBP**	29225-91-0		SVOC	1
Benzyltoluene	**BT**	27776-01-8		SVOC	1
Triallyl isocyanurate	**isoTAC**	1025-15-6		SVOC	1
Triallyl cyanurate	**TAC**	101-37-1		SVOC	1
2-Chlorotrityl chloride	**CTC *)**	42074-68-0		SVOC	1
2,3-Dibromopropanol	**DBP**	96-13-9		SVOC	2
3-Bromo-2,2-bis(bromomethyl) propanol	**TBNPA**	1522-92-5		SVOC	1
Chlorendic anhydride	**CEA**	115-27-5		SVOC	1
Benzenemethanol, 2-chloro-α,α-diphenyl-	**CTA *)**	66774-02-5		SVOC	1

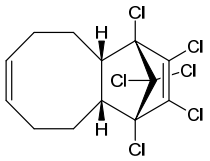
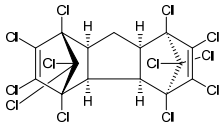
*): 2-Chlorotrityl chloride (CTC) are easily hydrolyzed to its derivative 2-Chlorophenyl)diphenyl-methanol (CTA). Only the sum of both components (CTC+CTA) could be determined. Throughout the rest of the report only CTC is given, which means the sum of CTC and CTA.

1.2.3 Dechloranes

Dechlorane compounds (DEC) which are used as flame retardant are listed in Table 3.

Table 3: Selected dechlorane compounds (DEC) with common name, acronyms used in this report, CAS number, chemical structure, and reference to sub-project number (1/2), priority compound (1-3), or extra compound (extra). Priority compounds are written in bold.

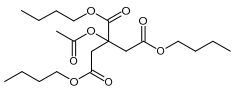
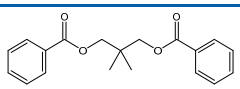
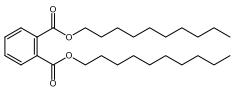
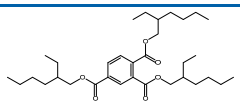
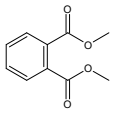
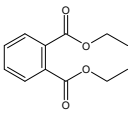
Name	Acronym	CAS	Structure	Group	Priority
Dibromaldrin	DBAldrin	20389-65-5		DEC	extra
Dechlorane 603	**Dec603**	13560-92-4		DEC	2
Dechlorane 602	**Dec602**	31107-44-5		DEC	2
Dechlorane 604	**Dec604**	34571-16-9		DEC	2
Dechlorane 601	Dec601	13560-90-2		DEC	2
Dechlorane plus	DP	3560-89-9			
Dechlorane plus syn	DPsyn	135821-03-3		DEC	extra
Dechlorane plus anti	DPanti	135821-74-8		DEC	extra
1,4-Methanobenzocyclooctene, 1,2,3,4,11,11-hexachloro-1,4,4a,5,6,7,8,10a-	**13DPMA**	70267-37-7		DEC	1

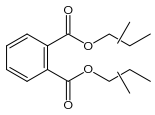
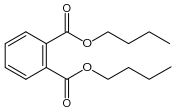
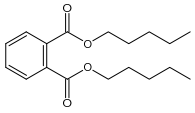
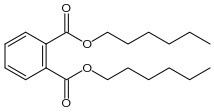
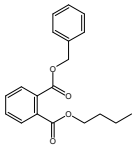
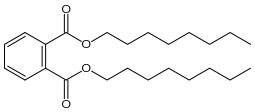
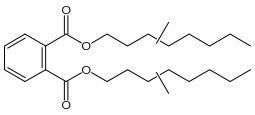
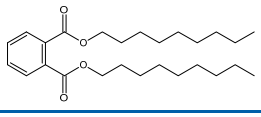
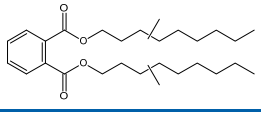
Name	Acronym	CAS	Structure	Group	Priority
octahydro-, (1α,4α,4aβ,10aβ)-					
1,4-Methanobenzocyclooctene, 1,2,3,4,11,11-hexachloro-1,4,4a,5,6,9,10,10a-octahydro-, (1R,4S,4aS,10aR)-rel-(9Cl, ACl)	**15DPMA**	135821-04-4		DEC	1
1,2,3,4,5,6,7,8,10,10,11,11-Dodecachloro-4,4a,4b,5,8,8a,9,9a-octahydro-1H-1,4:5,8-dimethanofluorene	**CdeneP**	13560-91-3		DEC	1

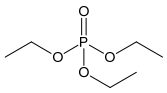
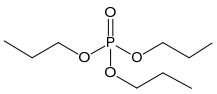
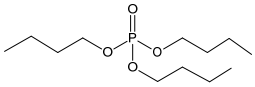
1.2.4 Plasticizers

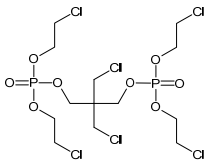
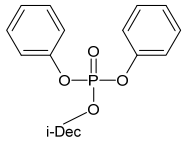
A set of substances used used as plasticizers, solvents, flame retardants, or other types of plastic additive were also included and listed in Table 4.

Table 4: Selected plasticizer compounds (Plast) with common name, acronyms used in this report, CAS number, chemical structure, priority compound (1-3), or extra compound (extra). Priority compounds are written in bold.

Name	Acronym	CAS	Structure	Group	Priority
Acetyl tributyl citrate	**ATBC**	77-90-7		Plast	1
Neopentyl glycol dibenzoate	**NPGD**	4196-89-8		Plast	1
Didecyl phthalate	**DDcP**	84-77-5		Plast	1
Tris(2-ethylhexyl) trimellitate	**TOTM**	3319-31-1		Plast	1
Dimethylphthalate	DMP	131-11-3		Plast	extra
Diethylphthalate	DEP	84-66-2		Plast	extra

Name	Acronym	CAS	Structure	Group	Priority
Phthalic acid diisobutyl ester	DiBP	84-69-5		Plast	extra
Di-n-butylphthalate	DnBP	84-74-2		Plast	extra
Bis(2-methoxyethyl) phthalate	BMEP	117-82-8		Plast	extra
Bis(4-methyl-2-pentyl)phthalate	DMPP	84-63-9		Plast	extra
Bis(2-ethoxyethyl)phthalate	BEEP	605-54-9		Plast	extra
Dipentylphthalate	DPP	131-18-0		Plast	extra
Di-n-hexyl phthalate	DHxP	84-75-3		Plast	extra
Benzyl butyl phthalate	**BBP**	85-68-7		Plast	1
bis(2-n-butoxyethyl) phthalate	DBOEP	117-83-9		Plast	extra
Bis(2-ethylhexyl)phthalate	DEHP	117-81-7		Plast	extra
Phthalic acid dicyclohexyl ester	DCHP	84-61-7		Plast	extra
Di-n-octyl phthalate	**DOP**	117-84-0		Plast	3
Di-iso-nonyl phthalate	DiNP	28553-12-0		Plast	extra
Di-n-nonyl phthalate	**DNP**	84-76-4		Plast	1
Di-iso-decyl phthalate	DiDP	26761-40-0		Plast	extra

Name	Acronym	CAS	Structure	Group	Priority
Triethyl phosphate	TEP	78-40-0		Plast	extra
Tripropyl phosphate	TPP	513-08-6		Plast	extra
Tri-n-butyl phosphate	TNBP	126-73-8		Plast	extra
Tris(2-chloroethyl) phosphate	TCEP	115-96-8		Plast	extra
Tris(2-chloroisopropyl) phosphate	TCIPP	13674-84-5		Plast	extra
Tris(2-butoxyethyl) phosphate	TBOEP	78-51-3		Plast	extra
Tris(1,3-dichloro-2-propyl)phosphate	TDCIPP	13674-87-8		Plast	extra
Triphenylphosphate	TPHP	115-86-6		Plast	extra
2-Etylhexyl-diphenylphosphate	EHDP	1241-94-7		Plast	extra
Tris(2-ethylhexyl) phosphate	TEHP	78-42-2		Plast	extra
2-isopropylphenyl diphenyl phosphate	2IPPDPP	64532-94-1		Plast	extra
ooo-Tricresylphosphate	TOTP	78-30-8		Plast	extra
mmm-Tricresylphosphate	TMTP	78-30-8		Plast	extra
4-isopropylphenyl diphenyl phosphate	4IPPDPP	55864-04-5		Plast	extra
ppp-Tricresylphosphate	TPTP	563-04-2		Plast	extra
Tris(2-isopropylphenyl) phosphate	T2IPPP	64532-95-2		Plast	extra
tris(3,5-dimethylphenyl) phosphate	T35DMPP	25653-16-1		Plast	extra
Bis(4-isopropylphenyl) phenyl phosphate	B4IPPPP	55864-07-8		Plast	extra
Tris(4-Tert-butylphenyl)phosphate	TTBPP	78-33-1		Plast	extra

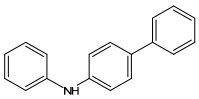
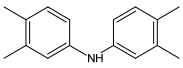
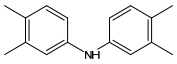
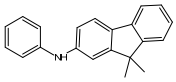
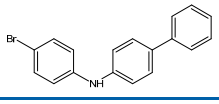
Name	Acronym	CAS	Structure	Group	Priority
Phosphoric acid, 2,2-bis(chloromethyl)-1,3-propanediyl tetrakis(2-chloroethyl) ester	**V6**	38051-10-4		Plast	1
Isodecyl diphenyl phosphate	**IDDPP**	29761-21-5		Plast	1

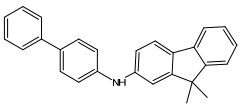
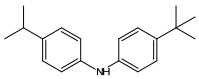
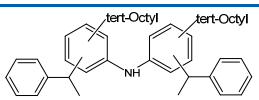
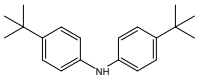
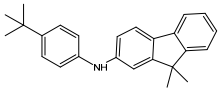
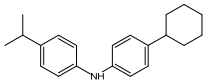
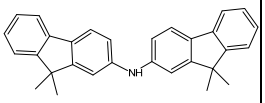
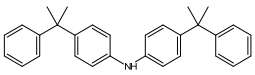
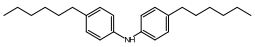
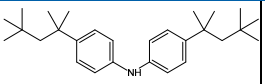
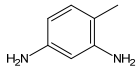
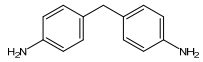
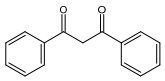
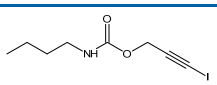
1.2.5 Secondary diphenyl amine compounds and analytically related compounds

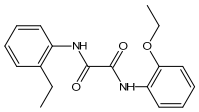
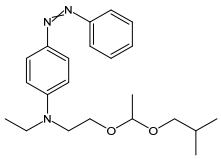
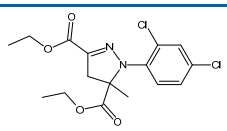
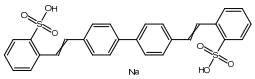
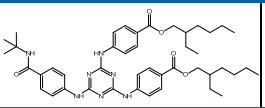
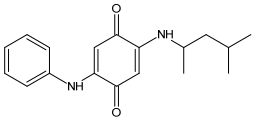
Selected secondary diphenyl amine compounds (SDPA) act as antioxidants in lubricants, especially in use where contact with food cannot be ruled out. Alkylated diphenylamines and other derivatives are also used as antiozonants in the manufacture of rubber products, due to the antioxidant nature of aniline derivatives. In addition, in this group some and some analytically related compounds were included with different use and application pattern, such as photoinitiator, fluorescent whitening agent, sunscreen, dye, and biocide.

In addition to the compounds selected by the Norwegian Environment Agency, based on a recent report on a toxicant related to road run-off responsible for acute mortality events for coho salmon (Tian, Zhao et al. 2021), the toxicant 6PPD-Q, was included on short notice. Selected compounds are shown in Table 5.

Table 5: Selected secondary diphenyl amine compounds (SDPA) with common name, acronyms used in this report, CAS number, chemical structure, priority compound (1-3), or extra compound (extra). Priority compounds are written in bold.

Name	Acronym	CAS	Structure	Group	Priority
N-Phenyl[1,1'-biphenyl]-4-amine	**PhDPA**	32228-99-2		SDPA	2
N-(3,4-Dimethylphenyl)-3,4-dimethylaniline	**TeMeDPA**	55389-75-8		SDPA	2
(4-tert-Butyl-phenyl)-phenyl-amine	**tBuDPA**	4496-49-5		SDPA	2
9,9-Dimethyl-N-phenyl-9H-fluoren-2-amine	**DiMeFluDPA**	355832-04-1		SDPA	2
N-(4-Bromophenyl)[1,1'-biphenyl]-4-amine	**BrPhDPA**	1160294-93-8		SDPA	2

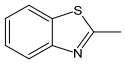
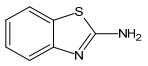
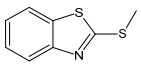
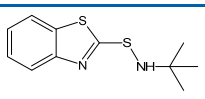
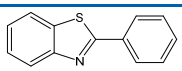
Name	Acronym	CAS	Structure	Group	Priority
N-([1,1'-Biphenyl]-4-yl)-9,9-dimethyl-9H-fluoren-2-amine	**PhDiMeFluDPA**	897671-69-1		SDPA	2
4-(1,1-Dimethylethyl)-N-[4-(1-methylethyl)phenyl] benzenamine	**iPrtBuDPA**	782504-35-2		SDPA	2
Mixture of compounds	**Naugalube**	68921-45-9		SDPA	2
Bis(4-tert-butylphenyl) amine	**DtBuDPA**	4627-22-9		SDPA	2
N-[4-(1,1-Dimethylethyl)phenyl]-9,9-dimethyl-9H-fluoren-2-amine	**BuDiMeFluDPA**	944418-46-6		SDPA	2
4-Cyclohexyl-N-[4-(propan-2-yl)phenyl]aniline	**iPrcHxDPA**	886365-92-0		SDPA	2
N-(9,9-Dimethyl-9H-fluoren-2-yl)-9,9-dimethyl-9H-fluoren-2-amine	**DiDiMeFluorenyl**	500717-23-7		SDPA	2
4-(2-Phenylpropan-2-yl)-N-[4-(2-phenylpropan-2-yl)phenyl]aniline	**diAMS**	10081-67-1		SDPA	2
Bis(4-hexylphenyl)amine	**DiHxDPA**	419566-33-9		SDPA	2
N,N-Bis(4-tert-octylphenyl)amine	**DitOcDPA**	15721-78-5		SDPA	2
2,4-Diaminotoluene	**DAT**	95-80-7		SDPA	1
4,4-Diaminodiphenyl methane	**MDA**	101-77-9		SDPA	1
Dibenzoylmethane	**DBM**	120-46-7		SDPA	1
3-Iodo-2-propynyl-N-butylcarbamate	**Iodocarb**	55406-53-6		SDPA	1

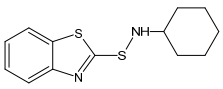
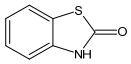
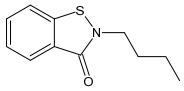
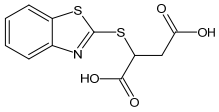
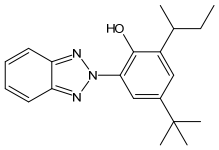
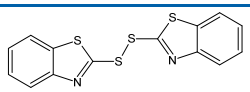
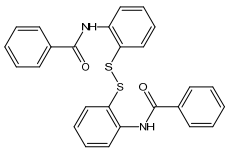
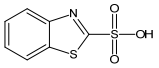
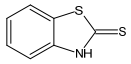
Name	Acronym	CAS	Structure	Group	Priority
N-(2-Ethoxyphenyl)-N'-(2-ethylphenyl) oxamide	**VSU**	23949-66-8		SDPA	1
N-Ethyl-N-(2-(1-(2-methylpropoxy) ethoxy)ethyl)-4-(phenylazo)aniline	**Solvent Y 124**	34432-92-3		SDPA	1
Mefenpyr-diethyl	**MFPDE**	135590-91-9		SDPA	1
Disodium 4,4'-bis(2-sulfostyryl)biphenyl	**Tinopal**	27344-41-8		SDPA	1
Iscotrizinol	**Isco**	154702-15-5		SDPA	1
6PPD-quinone	6PPDq	Not given yet		SDPA	extra

1.2.6 Benzothiazoles

Benzothiazole compounds (BTZ) used as catalyst, corrosion inhibitors, and vulcanization agents that were selected for screening in 2020 are shown in Table 6.

Table 6: Selected benzothiazole compounds (BTZ) with common name, acronyms used in this report, CAS number, chemical structure, priority compound (1-3), or extra compound (extra). Priority compounds are written in bold.

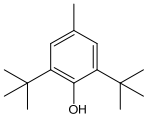
Name	Acronym	CAS	Structure	Group	Priority
Benzothiazole	BTZ	95-16-9		BTZ	extra
2-Methylbenzothiazole	MBTZ	120-75-2		BTZ	extra
2-Aminobenzothiazole	ABTZ	136-95-8		BTZ	extra
2-(Methylthio) benzothiazole	**MTBTZ**	615-22-5		BTZ	2
N-tert-Butyl-2-benzo-thiazolesulfenamide	**TBBS**	95-31-8		BTZ	1
2-Phenylbenzothiazole	PBTZ	883-93-2		BTZ	extra

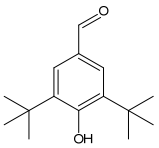
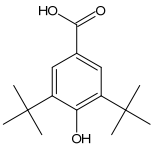
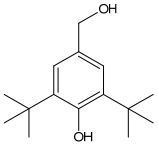
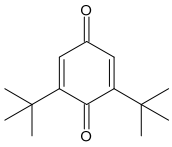
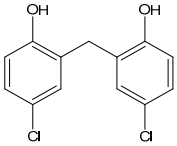
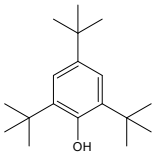
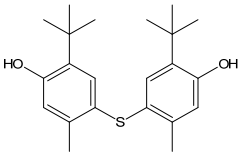
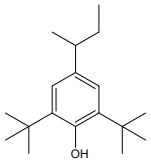
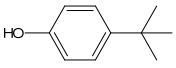
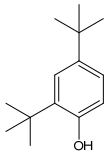
Name	Acronym	CAS	Structure	Group	Priority
N-Cyclohexyl-2-benzothiazole-sulfenamide	**CBS**	95-33-0		BTZ	1
2-Benzothiazolinone	HOBT	934-34-9		BTZ	extra
N-Butyl-1,2-benzisothiazolin-3-one	BBIT	4299-07-4		BTZ	extra
(2-Benzothiazolylthio) succinic acid	MTBS	95154-01-1		BTZ	extra
Phenol, 2-(2H-21ichloroethan-2-yl)- 4-(1,1-dimethylethyl)-6-(1-methylpropyl)-	**UV-350**	36437-37-3		BTZ	1
2,2'-Dithiobisbenzo-thiazole	**Altax**	120-78-5		BTZ	1
2,2'-Dibenzoylamino-diphenyl disulfide	**DTPB**	135-57-9		BTZ	1
2-Benzothiazolesulfonic acid	BTSA	941-57-1		BTZ	extra
2-Mercaptobenzo thiazole	**MBT**	149-30-4		BTZ	1

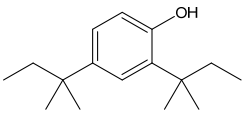
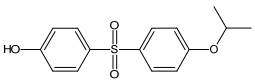
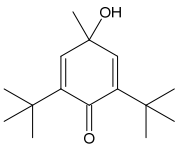
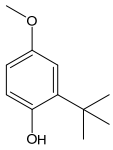
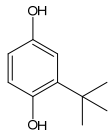
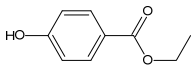
1.2.7 Phenolic compounds

Phenolic substances (Phenols) used as antioxidants, biocides, and some of their degradation products that were selected for screening in 2020 are listed in Table 7.

Table 7: Selected phenolic compounds (Phenols) with common name, acronyms used in this report, CAS number, chemical structure, priority compound (1-3), or extra compound (extra). Priority compounds are written in bold.

Name	Acronym	CAS	Structure	Group	Priority
Butylated hydroxytoluene	**BHT**	128-37-0		Phenols	3

Name	Acronym	CAS	Structure	Group	Priority
3,5-Di-tert-butyl-4-hydroxybenzaldehyde	**BHT-CHO**	1620-98-0		Phenols	2
3,5-Di-tert-butyl-4-hydroxybenzoic acid	BHT-COOH	1421-49-4		Phenols	extra
2,6-di-tert-butyl-4-(hydroxymethyl)phenol	**BHT-OH**	88-26-6		Phenols	2
2,6-Bis-(1,1-dimethylethyl)-2,5-cyclohexadiene-1,4-dione	**BHT-Q**	719-22-2		Phenols	3
Dichlorophen	**DCP**	97-23-4		Phenols	1
2,4,6-Tris(tert-butyl) phenol	**TTBP**	732-26-3		Phenols	3
4,4'-thiobis[2-(1,1-dimethylethyl)-5-methylphenol	**TBBC**	96-69-5		Phenols	1
4-(Butan-2-yl)-2,6-di-tert-butylphenol	**VANOX**	17540-75-9		Phenols	2
4-tert-butyl-phenol	**PTBP**	98-54-4		Phenols	2
2,4-di-tert-butyl- phenol	**24-DTBP**	96-76-4		Phenols	3

Name	Acronym	CAS	Structure	Group	Priority
2,4-Di-tert-pentylphenol	**DTAP**	120-95-6		Phenols	2
4-((4-Isopropoxy-phenyl)sulfonyl)phenol	**D8(HPS)**	95235-30-6		Phenols	1
2,6-Di-tert-butyl-4-hydroxy-4-methyl-2,5-cyclohexadien-1-one	**BHT-quinol**	10396-80-2		Phenols	2
2-tert-Butyl-4-methoxyphenol	**3-BHA**	121-00-6		Phenols	2
tert-Butyl hydroquinone	TBHQ	1948-33-0		Phenols	extra
Ethylparaben	**EP**	120-47-8		Phenols	1
Methyl-4-hydroxybenzoate	MP	99-76-3		Phenols	extra
Propyl-4-hydroxybenzoate	PP	94-13-3		Phenols	extra
Isopropyl-4-hydroxbenzoate	iPP	4191-73-5		Phenols	extra
Butyl-4-hydroxybenzoate	BuP	94-26-8		Phenols	extra
Isobutyl-4-hydroxybenzoate	iBuP	4247-02-3		Phenols	extra
Benzyl-4-hydroxybenzoate	BenzP	94-18-8		Phenols	extra
4,4’-Methylenebis(2,6-di-tert-butylphenol)	MB-DTBP	118-82-1		Phenols	extra
2,2’-Metylenebis(4-ethyl-6-tert-butylphenol)	MB-ETBP	88-24-4		Phenols	extra
3-(3,5-Di-tert-butyl-4-hydroxyphenyl) propionic acid	Fenozan	20170-32-5		Phenols	extra

Name	Acronym	CAS	Structure	Group	Priority
Butylated hydroxyanisole	BHA	25013-16-5		Phenols	extra
2,2'-Methylenebis (6-tert-butyl-4-methylphenol)	MB-MTBP	119-47-1		Phenols	extra
2,5-Di-tert-amylhydroquinone	DTAHQ	79-74-3		Phenols	extra
2,6-di-tert-butylphenol	26-DTBP	128-39-2		Phenols	extra

1.2.8 Surfactants

Selected surfactant compounds (Sur) and some of their degradation products were selected for screening in 2020 Table 8.

Table 8: Selected surfactant compounds (sur) with common name, acronyms used in this report, CAS number, chemical structure, priority compound (1-3), or extra compound (extra). Priority compounds are written in bold.

Name	Acronym	CAS	Structure	Group	Priority
N,N-Dimethyltetra-decan-1-amine N-oxide	**DTDA-oxide**	3332-27-2		SURF	1
N,N-Dimethyldodecyl-amine-N-oxide	**DDDA-oxide**	1643-20-5		SURF	2
N,N-Dimethyldodecan-1-amine	**DDDA**	112-18-5		SURF	2
N,N-Dimethyl-1-hexadecanamine	**DHDA**	112-69-6		SURF	2
N,N-Dimethyl-1-tetradecanamine	**DTDA**	112-75-4		SURF	2
N,N-Dimethyl-1-docosanamine	**DDOA**	21542-96-1		SURF	2
N,N-Dimethyl decylamine oxide	**DDA-oxide**	2605-79-0		SURF	2
N,N-Dimethyl-octylamine	**DOA**	7378-99-6		SURF	2
N,N-Dimethyl-1-octadecanamine	**DODA**	124-28-7		SURF	2

1.2.9 Compounds not possible to analyze and report

In total, more than 160 different compounds were included in the project. For 19 of the originally offered compounds, no analytical standards were available during the time frame of the project period due to long delivery times or technical problems to finalize a reliable detection and quantification method. These compounds are listed in Table 9 together with the reason for why quantitative analysis was not possible.

Several of the standards were not available for purchase and therefore required custom synthesis. However, during the COVID-19 situation the turnaround times for customer synthesis were extremely long and the products were not supplied in time for the final analysis.

Two substances used most commonly as pigments were insoluble in solvents compatible with trace analysis with GC- or LC-MS and could therefore not be included. A special case is 2,2-bis(bromomethyl)propane-1,3-diol was found to be too polar for the method-group it was originally assigned to and analysis was unsuccessful. Further development and revalidation of a single very specialized and time-consuming method solely for one compound was not feasible in the project timeframe so analysis was not performed.

Furthermore, C12−30 bromochloro alpha- alkenes are a complex mixture of many compounds and no isolated single compound standards or analytical method exists. NILU's lab in Tromsø tried to implement the analysis of this mixture into the SVOC-method. However, the mixture was too complex and consist of too many individual compounds to be included in the SVOC method. It was not possible to develop a specific method for all C12-30 bromochloro alkenes during the time fame of the project.

Several of the selected compounds were analysed by LC-MS/MS to achieve lower LoDs in line with accessible PNEC values. While improving the LoDs this limits the use of suspect screening or similar methods since by using LC-MS/MS no complete mass spectra are available and performing suspect screening was not possible.

Table 9: Compounds not possible to analyze and report in this study.

Compound	CAS	Group	Reasons
2,2-bis(bromomethyl)propane-1,3-diol	3296-90-0	SVOC	Requires specialized method for this single compound
C12−30 bromochloro alpha- alkenes	68527-01-5	SVOC	Complex mixture extensive method development required
Di-n-Oc-DPA	101-67-7	SDPA	Missing standard
DiPh-DPA	102113-98-4	SDPA	Missing standard
Perylene-3,4:9,10- tetracarboxy-diimideViolet 29, PTCDI	81-33-4	SDPA	Compound not dissolved
N,N'-1,2-ethanediylbis- octadecanamide	110-30-5	SDPA	Missing standard
9-octadecenoic acid (Z)-, methyl ester	112-62-9	SDPA	Missing standard

Compound	CAS	Group	Reasons
12-octadecadienoic acid (Z,Z)-, methyl ester	112-63-0	SDPA	Missing standard
Bisamide	123-26-2	SDPA	Missing standard
Dinatrium 4-amino-3-[[4[(2,4-di aminophenyl) azo][1,1-biphenyl]4-yl]azo]-5- hydroxy-6-(phenylazo) naphtalen-2,7-disulfonat (Direct Black 38)	1937-37-7	SDPA	Compound not dissolved
2,6-Dichloro-N- phenylaniline	15307-93-4	SDPA	Missing standard
N-ethyl-N-[2-(1-isobutoxyethoxy) ethyl]-4-(phenyldiazenyl)aniline	34432-92-3	SDPA	Missing standard
N,N'-(Benzene-1,3- diyldimethanediyl) bis(12- hydroxyoctadecanamide)	128554-52-9	SDPA	Missing standard
2-Mercaptobenzothiazole, zinc2(3H)-Benzothiazolethione, Zn saltMBT	155-04-4	BTZ	Missing standard
N-(1,1-dimethylethyl)bis(2-benzothiazolesulfen)amide	3741-80-8	BTZ	Missing standard
Dodecyldimethylamine oxide	1643-20-5	SURF	Missing standard
Octyldimethylamine oxide	2605-78-9	SURF	Missing standard
Decyl(dimethyl)amine oxide	2605-79-0	SURF	Missing standard
(Z,Z)-1-ethyl-2-(8-Heptadecenyl)-4,5-dihydro-1-[2-[(1-oxo-9-octa decenyl)amino]ethyl]-1H- imidazolium ethyl sulphate	67846-14-4	SURF	Missing standard

2 Sampling and analytical methods

2.1 Sampling stations, sample collection and sample pre-treatment

The screening program 2020 aims to fill knowledge gaps about additives in plastic materials. The compounds included in this investigation are related to products with a very wide area of use. This includes ingredients in products such as plastic, paint, car tires, rubber, electronics, textiles and household chemicals. The products can find use in private households, crafts and industry, laundries, and leisure boats. There is no clear information indicating that any of these compounds are produced in Norway, so emissions from factories during production are unlikely.

The environmental properties of the substances cover two extremes. On one hand, a large group of compounds with very low vapor pressure are included which are mainly used in solid products and articles. On the other hand, another large group is included consisting mostly of solvents which are relatively volatile and of limited water solubility. Any emissions of the latter compounds largely go to air. Several plastic additives have been detected in house dust in the past (Schlabach, van Bavel et al. 2017, Schlabach, Halse et al. 2019). For these air-related compounds, it was chosen to collect air samples at sites of potential emission, i) in homes (used/new/renovated), ii) in public buildings (furniture/clothes/outdoor equipment stores, offices, kindergartens and a museum), iii) in cars (used/new) and car-related indoor environments (e.g. wash facilities and retailers), and iv) at artificial turfs.

Rubber-related compounds are linked to car tires and road dust. Sampling sites therefore include water from road tunnel washing, vehicle washing facilities and winter storage space for small boats. Wastewater from residential areas and industrial areas, together with the Bekkelaget wastewater treatment plant and the Alna watercourse are also selected.

In the Screening program 2015, several other compounds were detected in both outlets from treatment plants and in leachate from landfills (Van Bavel et al., 2016). Based on this information, and to get a better and more detailed overview of the pattern of use and the pattern of emissions of the various compounds, it was proposed to use Alna Valley, the east side of the Oslofjord, with the Alna watercourse up towards Alnabru and adjacent residential areas, as a model system. Previous studies have shown that this area is generally heavily burdened by many environmental pollutants.

The following samples were collected for analysis:

1. Wastewater from residential areas, industrial areas, tunnel washes and vehicle washes in Groruddalen and Alna area.
2. Wastewater effluent and sludge from Bekkelaget Wastewater Treatment Plant.
3. Soil from leisure-boat storage marinas.
4. Artificial turfs from sports/training sites and rubber flooring (outdoor/indoor/new materials).

5. Indoor air and settled dust from residential, public buildings and furniture / clothes / outdoor equipment store.
6. Indoor air and settled dust from cars and car-related indoor environments.
7. Herring gull eggs from the Inner Oslo Fjord that represent both a contaminated marine and terrestrial food chain (sampling under the auspices of the Urban Fjord project).

NIVA performed sampling of all water-related and biota samples, while NILU carried out sampling of air, dust, and turf.

Sampling and handling of the samples was carried out in the cleanest possible way to minimize risk of contamination. One of the measures was to avoid the use of personal care products such as shampoos and creams one day before collection of samples. The guidelines for sampling to the Environmental Specimen Bank were used where possible (ESB 2021).

2.1.1 Indoor environmental samples

Samples from indoor environments was carried out in both residential and public environments. In total, 13 residential sites and nine public sites in the Oslo area were included. The sites were selected to cover both newly constructed/renovated and older existing and not recently renovated sites, to the extent it was possible (Table 10). The public environments included kindergartens, stores, offices and a museum. At some public sites, samples were collected at more than one location resulting in a total number of 12 samples from public sites. The residential sites included terrace houses (TH), single-family houses (SFH) and apartments (AB).

Table 10: Description of the indoor sampling sites and samples collected at each site.

Site ID	Type*	Details	Age/ condition	Dust	Air
Public 1	NRB	Shop	Old	Floor dust	Active air sampling (30 min), Tenax
Public 2	NRB	Shop	Old	Floor dust	Active air sampling (30 min), Tenax
Public 3	NRB	Shop	Old	Floor dust	Active air sampling (30 min), Tenax
Public 4**	NRB	Office	Old	Floor dust/Wipes	Passive air sampling (1 week), Tenax
Public 5**	NRB	Shop	Old	Floor dust	Active air sampling (30 min), Tenax
Public 6	NRB	Kindergarten	Old	Floor dust	Passive air sampling (1 week), Tenax
Public 7**	NRB	Kindergarten	New	Wipes	Passive air sampling (1 week), Tenax
Public 8	NRB	Museum	New	Wipes	Active air sampling (30 min), Tenax
Public 9	NRB	Office	Renovated	Floor dust	Passive air sampling (1 week), Tenax

Site ID	Type*	Details	Age/ condition	Dust	Air
Private 1	SFH	Split	Old	Floor dust	Passive air sampling (1 week), Tenax
Private 2	SFH	Split	Old	Floor dust	Passive air sampling (1 week), Tenax
Private 3	SFH	Split	Old	Floor dust	Passive air sampling (1 week), Tenax
Private 4	TH		Old	Floor dust	Passive air sampling (1 week), Tenax
Private 5	SFH	Split	Old	Floor dust	Passive air sampling (1 week), Tenax
Private 6	SFH		Old	Floor dust	Passive air sampling (1 week), Tenax
Private 7	SFH		Old	Floor dust	Passive air sampling (1 week), Tenax
Private 8	AB		Old	Floor dust	Passive air sampling (1 week), Tenax
Private 9	AB		Old	Floor dust	Passive air sampling (1 week), Tenax
Private 10	TH		Old	Floor dust	Passive air sampling (1 week), Tenax
Private 11	SFH		New	Wipes	Passive air sampling (1 week), Tenax
Private 12	SFH		Renovated	Floor dust	Passive air sampling (1 week), Tenax
Private 13	SFH	Split	Renovated	Floor dust	Passive air sampling (1 week), Tenax

*SFH: Single-Family House; TH: Terrace House; AB: Apartment Block; NRB: Non-residential building
**Samples collected from more than one location within this site.

The screening of indoor environments was performed by collecting settled dust samples and air samples. The settled dust samples were collected from floors with a specially designed vacuum cleaner in most indoor environments. A few sites either lacked electricity supply or the floor-dust was not representative of the building (e.g. construction site), so in these cases dust was collected from a mix of horizontal and vertical surfaces. Air samples were collected on Tenax TA adsorbent tubes. The tubes were deployed for one week as passive air samplers at the residential sites, kindergartens and offices. At shops and the museum, the tubes were deployed for just 30 min using an active sampling approach. The sampling was conducted in the main living area of the residential sites, and in representative areas of the public sites. At shops, the active sampler was placed in 3-4 places during the 30 min sampling to obtain a sample representative of all the shop. All samples were collected at 1-2 m height. Details on sampling sites are given in Table 10.

2.1.1.1 Potential hotspots

The selection of potential hotspots was based on the use categories for targeted chemicals. Special focus in 2020 was put on cars and car-related sites such as washing facilities and car retailers. Artificial turfs from football fields, and rubber playground mats/flooring were also included. The sampling included three used cars, three new electrical cars, three car retailers, three vehicle washing facilities, three bus washing facilities, seven artificial turfs and two playgrounds with rubber flooring(Table 11). The three used cars were sampled before and after an internal washing of the car. The seven artificial turfs included three outdoor and two indoor sites with normal rubber granules and two outdoor sites with olive stone fillings.

Table 11: Description of the potential hotspots sites and samples collected at each site.

Site ID	Details	Age/ condition	Dust	Air	Granules
Car 1	Before wash	Old	Wipes	Active air sampling (30 min), Tenax	
Car 2	Before wash	Old	Wipes	Active air sampling (30 min), Tenax	
Car 3	Before wash	Old	Wipes	Active air sampling (30 min), Tenax	
Car 4	After wash	Old	Wipes	Active air sampling (30 min), Tenax	
Car 5	After wash	Old	Wipes	Active air sampling (30 min), Tenax	
Car 6	After wash	Old	Wipes	Active air sampling (30 min), Tenax	
Car 7	New	2020	Wipes	Active air sampling (30 min), Tenax	
Car 8	New	2020	Wipes	Active air sampling (30 min), Tenax	
Car 9	New	2020	Wipes	Active air sampling (30 min), Tenax	
Car 10	Car retailer		Floor dust	Active air sampling (30 min), Tenax	
Car 11	Car retailer		Floor dust	Active air sampling (30 min), Tenax	
Car 12	Car retailer		Floor dust	Active air sampling (30 min), Tenax	
Vehicle wash 1	Cars – automatic		Wipes	Active air sampling (30 min), Tenax	
Vehicle wash 2	Cars – manual		Wipes	Active air sampling (30 min), Tenax	
Vehicle wash 3	Cars – automatic		Wipes	Active air sampling (30 min), Tenax	
Vehicle wash 4	Bus – automatic		Wipes	Active air sampling (30 min), Tenax	

Site ID	Details	Age/ condition	Dust	Air	Granules
Vehicle wash 5	Bus – automatic		Wipes	Active air sampling (30 min), Tenax	
Vehicle wash 6	Bus – automatic	Semi-outdoors	Wipes	Active air sampling (30 min), Tenax	
Artificial turf 1	Rubber granules	Outdoors	Airborne	Active air sampling (30 min), Tenax	Rubber granules
Artificial turf 2	Olive stones/sand	Outdoors	Airborne	Active air sampling (30 min), Tenax	Olive stone/sand
Artificial turf 3	Rubber granules	Indoors	Airborne	Active air sampling (30 min), Tenax	Rubber granules
Artificial turf 4	Rubber granules	Outdoors	Airborne	Active air sampling (30 min), Tenax	Rubber granules
Artificial turf 5	Rubber granules	Indoors	Airborne	Active air sampling (30 min), Tenax	Rubber granules
Artificial turf 6	Rubber granules	Outdoors	Airborne	Active air sampling (30 min), Tenax	Rubber granules
Artificial turf 7	Olive stones/sand	Outdoors	Airborne	Active air sampling (30 min), Tenax	Olive stones/Sand
Rubber flooring 1	Playland	Indoors	Floor dust*	Active air sampling (30 min), Tenax	Rubber flooring
Rubber flooring 2	Kindergarten, New	Outdoors	Floor dust*	Active air sampling (30 min), Tenax	Rubber flooring
Rubber flooring 2	Kindergarten, Old	Outdoors		Active air sampling (30 min), Tenax	Rubber flooring

*Dust from these sites are also used as new/old public sites in Table 11.

Figure 1: Sampling of settled dust and air in cars and car retailers. (Photo: Heidi Eikenes, Helene Lunder Halvorsen, Pernilla Bohlin-Nizzetto, NILU.)

Figure 2: Sampling of air and surface dust at vehicle washing facilities. (Photo: Heidi Eikenes, Helene Lunder Halvorsen, Pernilla Bohlin-Nizzetto, NILU.)

Figure 3: Sampling of air, granules and deposition of airborne plastic particles at artificial turfs. (Photo: Heidi Eikenes, Helene Lunder Halvorsen, Pernilla Bohlin-Nizzetto, NILU.)

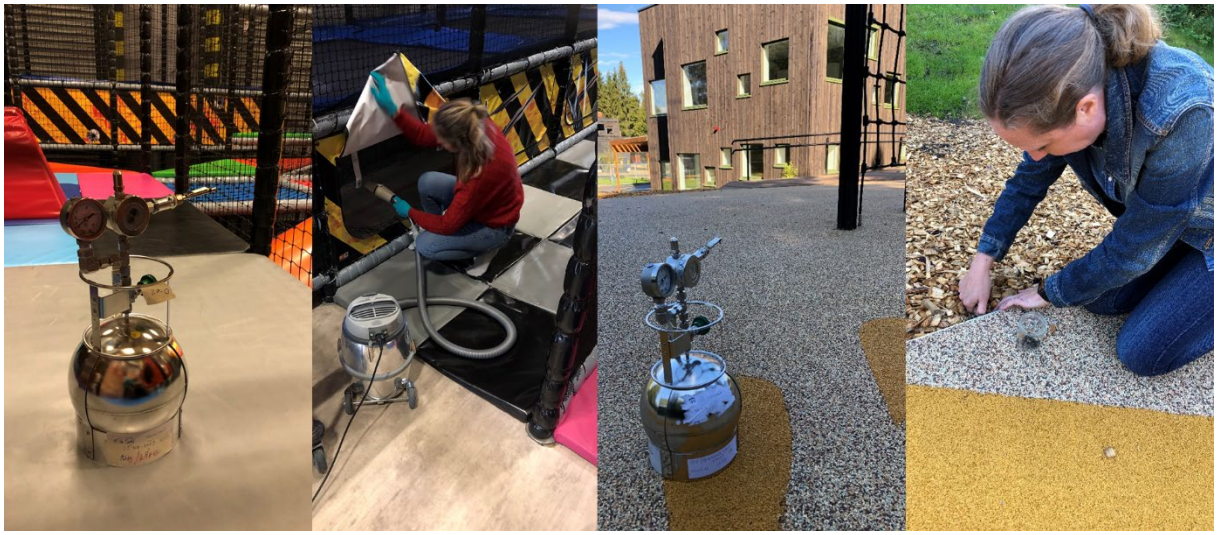


Figure 4: Sampling of air, settled dust and granule sampling on rubber flooring playgrounds. (Photo: Heidi Eikenes, Helene Lunder Halvorsen, Pernilla Bohlin-Nizzetto, NILU.)

The screening of potential hotspots was performed by collecting air samples, settled floor dust (where possible), surface dust (wipes), deposition of airborne particles and granules. Settled dust samples were collected from floors at car retailers and a playland with the specially designed vacuum used in indoor environments. A mix of horizontal and vertical surfaces were sampled with wipe samples in cars and vehicle washing facilities. All dust and wipes samples were normalized to the sampled area to obtain comparable data.

Air samples were collected on Tenax TA adsorbent tubes. The tubes were deployed for 30 min using an active sampling approach. The tubes were placed in 3-4 places during the 30 min sampling to obtain a combined representative sample of each site. Granule samples were collected from the artificial turfs and one of the rubber flooring playgrounds. Details on sampling sites are given in Table 11.

2.1.1.2 Air sampling methodologies

Air samples were collected on Tenax TA (300 mg) adsorption tubes. The Tenax TA is a suitable adsorbent for air sampling of volatile organic chemicals (VOCs) and covers a broad spectrum of VOCs (C5-C17) with various functional groups and volatility. It can be used as passive or active sampler. The passive sampler is exposed and samples over one week (sample volume: 4 L per week) while the active sampler samples for a shorter period (here 3 L for approximately 30 min). Before exposure, all Tenax TA tubes were re-conditioned and pre-cleaned by thermal desorption and immediately sealed with Swagelock end caps to minimize risk of contamination. At site, the Tenax TA tubes were opened and placed on an elevated position in the room or placed on the active sampler and exposed according to Figure 5.

Figure 5: Air sampling in indoor residential and public environments. Tenax TA tubes as passive air samplers (2 images left) and active air samplers (2 images right). (Photo: Heidi Eikenes, Helene Lunder Halvorsen, Pernilla Bohlin-Nizzetto, NILU.)

2.1.1.3 Dust sampling strategies

Floor dust samples were collected on a cellulose filter using an industrial vacuum cleaner (Nilfisk GM 80P) equipped with a special forensic nozzle with a one-way filter housing (KTM AB, Bålsta, Sweden) placed in the front of the vacuum cleaner tube (Bornehag, Sundell et al. 2004, Huber, Haug et al. 2011) (Figure 6). The participants in residential environments were asked to clean normally until one week before sampling and then not to vacuum clean or wet clean the floors in the living room so that all settled floor dust samples would reflect an accumulation time of approximately one week. In public environments, settled dust was collected without any preparation. After sampling a lid was put on the filter housing, and the whole sampling compartment was wrapped in double layers of alumina foil, placed in two sealed plastic bags and stored cold until sample preparation. The filter housings were weighed before and after sampling in order to measure the total amount of collected dust. Before the second weighing, larger pieces in the dust (such as hair, food, and stones etc.) were discarded leaving a defined dust sample. The amount of dust was used to obtain measurements in nanogram per gram of dust, and to allow for an estimate of the dust-loading at each site. Each floor dust sample (including the cellulose filter) was then split into fractions ranging from 100-200 mg of dust each, for the individual extraction and analytical steps.

When floor dust was not possible to collect, the dust was instead collected using wipe samples of horizontal and vertical surfaces. The wipe samples were collected using glass fiber filters (142 mm) soaked in solvent. The glass fiber filters were pre-cleaned at 450˚C before sampling. At each site 5-6 wipe samples were collected to cover a representative surface area. All wipes from one site were packed together in alumina foil, placed in two sealed plastic bags and stored cold until sample preparation. The wipes were extracted together to obtain a composite sample from each site.

Figure 6: Sampling of settled dust in indoor residential and public environments with wipes (left) and vacuum cleaner (right). (Photo: Heidi Eikenes, Helene Lunder Halvorsen, Pernilla Bohlin-Nizzetto, NILU.)

In order to separate between granules and dust samples at artificial turfs, an atmospheric deposition collector was used as a proxy of dust. The deposition collector is especially designed to sample deposition of airborne plastic particles. It consists of a stainless-steel container that is deployed on 1.5-2 m height (Figure 3). The collector was pre-cleaned before field deployment and then deployed for four weeks at each site. After collection a lid was added, and the collector was stored cold until sample preparation. The deposited particles were transferred to a glass fiber filters (50 mm) by rinsing the deposition collector with MilliQ water through a filtration system.

2.1.1.4 Granule sampling strategies

Granule samples were collected at artificial turfs and at the outdoor playground site. At the artificial turf sites the rubber granules or olive stones/sand were collected in glass jars using a metal spoon. Rubber granules and olive stones/sand were collected from various areas of the football fields to obtain a representative sample. At the playground, melted rubber pieces were taken out on the sides of the flooring area using a metal knife and spoon.

2.1.2 Sampling of municipal wastewater and final treated sludge

2.1.2.1 Municipal wastewater / sludge

Flow-proportional 24-hour composite samples of treated effluent were collected from the Bekkelaget wastewater treatment plant (WWTP). The plant's own automatic composite sampler (ISCO) was used for sampling. Table 12 shows the period for sampling, the total amount of wastewater that was treated at the plant during each sampling campaign (full and/or reduced treatment), as well as the suspended solids (SS) concentration in each individual water sample (measurements made by the plant itself).

In addition, samples were collected of stabilized dewatered sludge (the same that is transported away from the plant). The samples were taken as daily grab samples on weekdays from each of the centrifuges in use at the facilities at the time of sampling. Each subsample was frozen and transported to NIVA where they were thawed before preparation of the composite sample, which was then frozen again.

The total sludge production at the plant as well as the solids content and organic content (loss on ignition; LOI) of the sludge during each sampling period (measurements made by the plant itself) are detailed in Table 12.

Table 12: Period for sampling of treated effluent for analysis of environmental contaminants at Bekkelaget WWTP. The samples were taken as water flow-proportional samples with the facilities own automatic composite sampler. The concentration of suspended matter (measurements from Bekkelaget WWTP) and the amount of wastewater that was treated at the plant during each sampling campaign (full and/or reduced treatment).

Conditions	Start	End	SS	Total treated volume	Reduced treatment*
	-	-	mg/L	m^3	m^3; %
Dry weather	19.08.2020 08:00	20.08.2020 08:00	3,4	104 804	0; 0,00
Reduced operation	21.08.2020 08:00	24.08.2020 08:00	9,3	475 964	1 741; 0,37
Dry weather	31.08.2020 08:00	01.09.2020 08:00	6,6	115 540	0; 0,00
Dry weather	01.09.2020 08:00	02.09.2020 08:00	6,5	113 965	0; 0,00
Dry weather	02.09.2020 08:00	03.09.2020 08:00	6,4	114 073	0; 0,00
Dry weather	22.09.2020 08:00	24.09.2020 08:00	16,5	247 505	0; 0,00
Dry weather	24.09.2020 08:00	25.09.2020 08:00	12,4	169 079	785; 0,46
Reduced operation	05.10.2020 08:00	06.10.2020 08:00	13,1	194 962	1 779; 0,91
Reduced operation	07.10.2020 08:00	08.10.2020 08:00	12,5	243 992	3 971; 1,63
Reduced operation	08.10.2020 08:00	09.10.2020 08:00	11,2	237 047	3 651; 1,54

*) Chemical treatment after pre-sedimentation (bypass biological treatment)

Table 13: Period for sampling of final treated sewage sludge taken at Bekkelaget WWTP. Total sludge production during the period that the sampling represented, as well as the sludge's dry matter content (TS) and organic content (loss on ignition; LOI) (measurements from Bekkelaget WTTP).

Conditions	Date	Sludge production		TS	LOI
	-	ton TS	ton TS/d	%	%
Dry weather	19.-20.08.2020	4,0	4,0	32,97	46,1
Reduced operation	21.-24.08.2020	13,9	4,6	31,68	46,9
Dry weather	31.08-01.09.2020	5,0	5,0	28,02	46,4
Dry weather	01.-02.09.2020	5,5	5,5	28,02	46,4
Dry weather	02.-03.09.2020	6,2	6,2	27,35	46,2
Dry weather	22.-24.09.2020	9,0	3,0	30,51	45,8
Dry weather	24.-25.09.2020	5,0	5,0	30,05	45,3
Reduced operation	05.-06.10.2020	3,9	3,9	29,84	45,6
Reduced operation	07.-08.10.2020	4,6	4,6	30,33	46,3
Reduced operation	08.-09.10.2020	5,6	5,6	28,28	46,8

2.1.2.2 Sampling of microplastic particles (> 50 µm) in effluent

Effluent water at Bekkelaget WWTP was directly filtered through a set of sieves with pore sizes of 300 µm, 100 µm and 50 µm in a specially designed filter set-up by pumping (1.5-6.0 L / min) of effluent from the same overflow tray where the plant itself takes out their own 24-hour composite samples from the effluent (see Figure 7). The total amount of water that had passed through the filter setup was measured with a water meter (JET, Sensus GmbH). This amount, as well as the total amount of wastewater treated at the plant during each individual sampling period, are shown in Table 13. The collected particles were washed off the individual sieve with double-filtered tap water and transferred to an annealed glass jar (the material collected on the 300 µm and 100 µm sieves were transferred to the same glass, while the material collected on the 50 µm screen was transferred to a separate glass). The particles were then disinfected with alcohol and washed again with double-filtered tap water, before the glass jars were transported to NIVA and frozen at -20 ° C until further sample preparation.

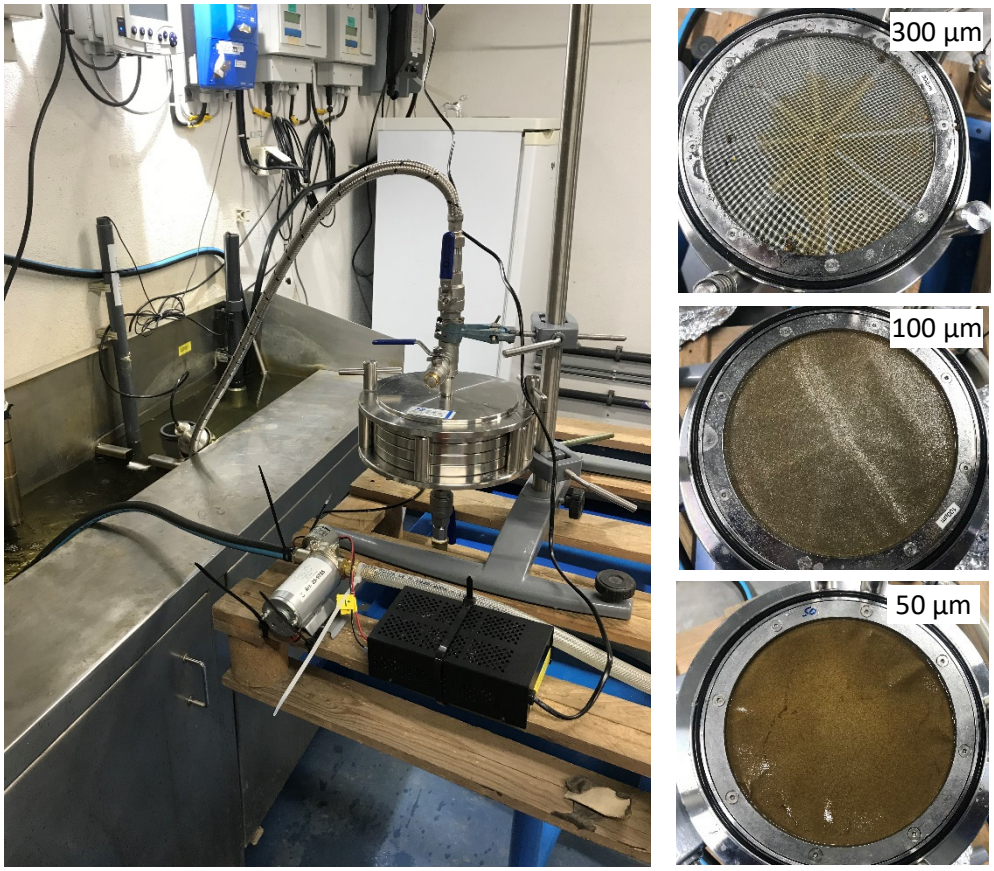


Figure 7: Setup for sampling microplastics in the effluent from Bekkelaget WWTP. The sieves to the right show the collected material after sampling on October 8th 2020. (Photo: Christian Vogelsang, NIVA.)

Table 14: Period for sampling of treated effluent for analysis of microplastics at Bekkelaget WWTP. The amount sampled corresponds to the amount of discharge water that had passed through the filter set-up, while the treated amount corresponds to the total amount of wastewater that had been treated (full and/or reduced treatment) at the treatment plant during each sampling period.

Sample Conditions	Start	End	Sampled amount	SS	Treated amount	Reduced treatment
	-	-	L	mg/L	m^3	m^3;%
Reduced operation	01.09.2020 12:00	02.09.2020 11:20	8421	6,5	110 493	0; 0,00
Dry Weather	02.09.2020 12:00	03.09.2020 13:00	2321	6,4	115 335	0; 0,00
Dry Weather	24.09.2020 09:20	24.09.2020 12:40	447	16,5	21 846	30; 0,14
Reduced operation	07.10.2020 09:20	07.10.2020 11:30	473	12,5	21 954	358; 1,63
Reduced operation	07.10.2020 11:44	07.10.2020 13:18	347	12,5	15 916	258; 1,62
Reduced operation	08.10.2020 12:53	08.10.2020 15:22	650	12,5	25 074	409; 1,63

*) Chemical treatment after pre-sedimentation (bypass biological treatment)

2.1.3 Sampling of river water and river sediment

Six water samples were collected at each of two stations along Alna: Breivoll and Kværner. Breivoll is just downstream of the main industrial area in the Alna area. Coordinates are shown in Table 15 and further location in Figure 8. The samples were collected as time-proportional 24-hour composite samples (50 mL or 100 mL every 5 min or 10 min) with an automatic composite sampler (ISCO). Four of the six samples were taken in connection with rainfall events. The reported water flow is at Oslo Municipality's measuring station "Kværnerristen" approx. 3.5 km further downstream. The stream Østensjøbekken enters along this stretch of river in addition to some smaller streams, so the indicated water flow probably overestimates the water flow at Breivoll by approximately 25% based on the relative sizes of the two catchment areas.

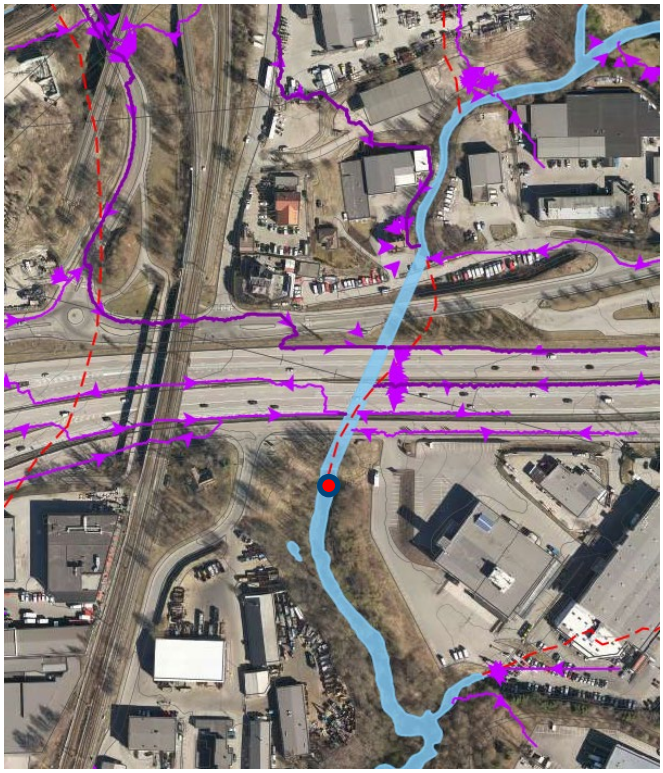
Kværner is just before the river Alna flows into a culvert that ends in the Inner Oslo Fjord (but does not include the main municipal overflow from the sewer network). Coordinates are shown in Table 15 and further location in Figure 8. The samples were taken as time-proportional 24-hour composite samples (50 mL or 100 mL every 5 min or 10 min) with an automatic composite sampler (Avalange). Four of the six samples were taken in connection with rainfall events. The reported water flow is at Oslo Municipality's measuring station at the same location ("Kværnerristen").

2.1.3.1 River sediment

A total of six river sediment samples were collected along Alna, two from each of three stations: Brubak (N 6646841.48, Ø 604959.57), Breivoll (N 6644277.7, Ø 602599.79) and Kværner (N 6642145.67, Ø 600215.49) on the dates 08.07.2020 and 01.09.2020. Each sample was collected as composites of five equally sized grab samples of the upper 2 cm sediment within an area of approximately 25 m^2. River sediment was used for microplastic analyses instead of the original planned water samples where too little material was collected to achieve the required detection limits. Sediments on the other hand are a sink for microplastics and the samples therefore contained sufficient material for subsequent analysis.

Table 15: Period for sampling at the stations Breivoll and Kværner along the river Alna. Rainfall before and during the sampling period (data from Frost API (met.no) at the weather station Oslo – Blindern SN8700), as well as the amount of water that had passed a and the average water flow during each sampling campaign as measured at Oslo municipality's sampling station "Kværnerristen".

Station	Start	End	Rainfall 1 week before	Rainfall 24 h before	Rainfall during	Amount of water	
			mm	mm	mm	m^3	m^3/time
Breivoll (N6644277.7 Ø602599.79)	08.07.2020 12:00	09.07.2020 12:00	64,1	8,2	2,1	143 871	5 995
	01.09.2020 14:30	02.09.2020 14:30	0,6	0,0	0,0	30 442	1 268
	02.09.2020 14:30	03.09.2020 14:20	0,0	0,0	0,0	29 357	1 232
	04.09.2020 12:20	04.09.2020 16:30	2,9	2,9	0,0	9 850	2 364
	07.09.2020 11:30	08.09.2020 11:30	4,5	0,0	3,6	49 779	2 074
	23.09.2020 08:00	23.09.2020 12:30	0,5	0,3	2,2	18 353	4 078
Kværner (N6642145.67 Ø600215.49)	09.07.2020 14:00	10.07.2020 09:00	62,6	2,1	0,0	75 196	3 958
	01.09.2020 13:00	02.09.2020 12:30	0,9	0,0	0,0	29 879	1 271
	02.09.2020 12:30	03.09.2020 03:00	0,0	0,0	0,0	17 923	1 236
	04.09.2020 09:10	04.09.2020 13:20	2,9	2,9	0,0	17 207	4 130
	07.09.2020 12:30	08.09.2020 05:00	4,5	0,0	3,6	36 761	2 228
	24.09.2020 09:45	24.09.2020 14:00	14,1	12,2	10,5	23 167	5 451



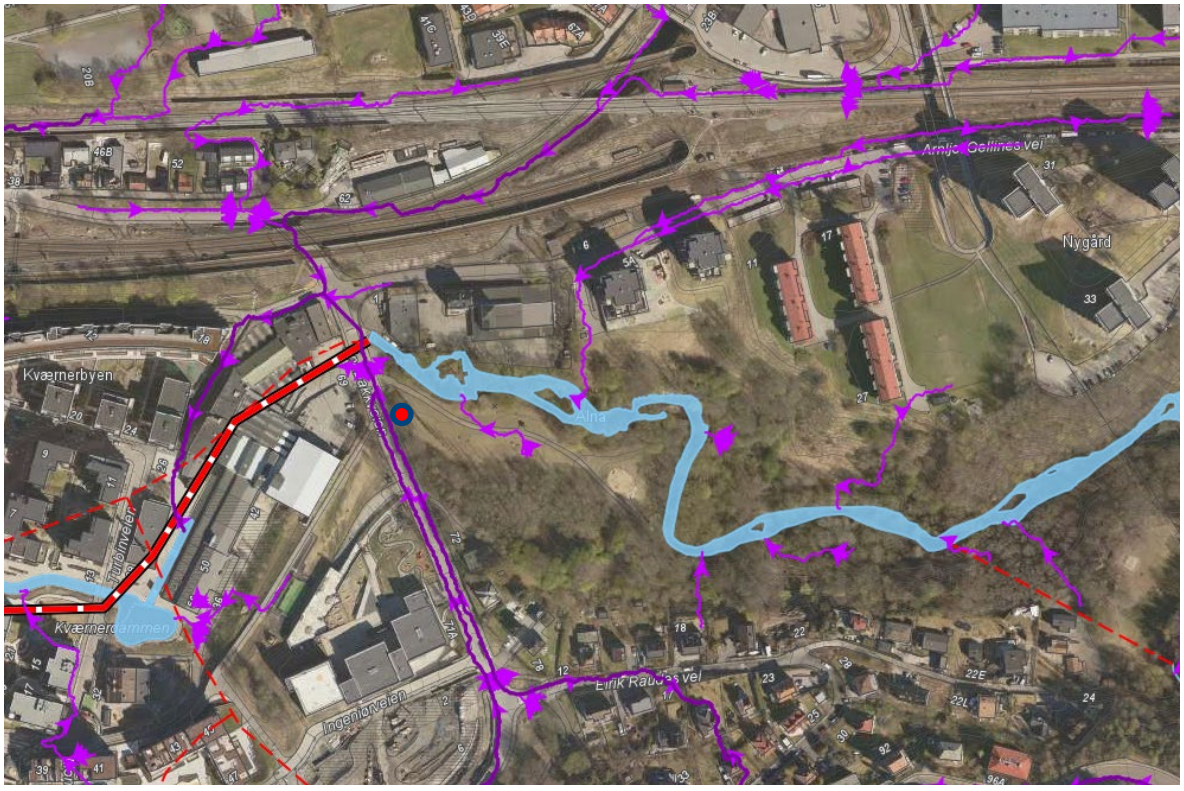


Figure 8: The location of the sampling stations along Alna: A) Breivoll, in the left side tunnel. B) Kværner. The red dots indicate the sampling points. The purple lines indicate theoretical drainage lines in the area. (Phot: Christian Vogelsang, NIVA.)

2.1.4 Tunnel wash water and sediment from tunnel gully-pots

Sediment from gully-pots and tunnel wash water was collected during a tunnel wash of the Smestad tunnel in Oslo (59◦56'16" N, 10◦41'2" Ø). The tunnel is 500m long and the traffic is separated by tunnel corridors for each driving directions. The samples were collected in the direction going westwards, where the Annual Average Daily Traffic (AADT) was 44 060 vehicles per day, in which 8% was heavy vehicles.

2.1.4.1 Gully-pots

Before the tunnel was washed, three gully-pots inside the tunnel were selected. The chosen gully-pots represent the inlet (100m in, by the driving direction), the middle of the tunnel (250m in) and the end of the tunnel (400m in). The sediment samples were collected using a small Van Veen sediment sampler and the samples were collected in pre-cleaned (rinsed with filtered (0.45µm) RO-water) aluminum beakers. Sub-samples were taken from this material with pre-cleaned metal spoons and collected in glass jars (pre-cleaned by muffle furnace to remove potential contamination from polymers). The top was covered in aluminum foil before the lid was put on.

Figure 9: Sediment from gully-pots were collected using a small Van Veen sediment sampler. (Photo Elisabeth Rødland, NIVA.)

2.1.4.2 Tunnel wash water

The samples were collected during a «full-wash» of the tunnel, which includes washing of the road surface, the tunnel walls and all the technical equipment. Before the wash starts, road dust and larger gravel was removed as much as possible and transported away from the tunnel. Immediately after the wash starts, water will flow into the gully-pots and be transported to the pump station outside of the tunnel via the tunnels drainage system. After reaching a certain water level, the pump will transfer the wash water to the sedimentation basin, where the tunnel wash water was treated for three weeks

before it was released into a rain-garden for a second treatment by infiltration. From the rain-garden it will flow into the surrounding environment and into the Smestad pond.

All samples were collected in the pump station before the water was transported to the sedimentation basin. The samples were taken using a pump. Water was constantly pumped up from the pump station and sample bottles were collected in the beginning of the wash, in the middle of the wash and in the end of the wash.

Table 16: Sample overview for gully-pot and tunnel wash water sampling in the Smestad tunnel.

Location	Sample description	Sample type	Sample type
100m in the tunnel	Gully-pot, inlet	Sediment (3)	Water (3)
250m in the tunnel	Gully-pot, middle	Sediment (3)	Water (3)
400m in in tunnel	Gully-pot, outlet	Sediment (3)	Water (3)
Pump station	Wash water, start	Sediment (3)	Water (3)
Pump station	Wash water, mid	Sediment (3)	Water (3)
Pump station	Wash water, end	Sediment (3)	Water (3)

Figure 10: Sampling of tunnel wash water during a tunnel wash in the Smestad tunnel pump station. (Photo: Elisabeth Rødland/Sondre Meland, NIVA)

2.1.5 Biological samples

2.1.5.1 Blue mussels

Blue mussel samples (Mytilus edulis) were taken at several location in the inner Oslo fjord at the 24th and the 25th of August. Most blue mussel samples were collected from floating jetties in the marina at the different locations given in Table 17.

Table 17. Sample locations in the inner Oslo for the mussel samples.

Sample location	Latitude	Longitude	Sample type
Hovedøya	59.898	10.737	± 30 Blue Mussels (Mytilus edulis)
Hovedøya	59.898	10.737	± 30 Blue Mussels (Mytilus edulis)
Hovedøya	59.898	10.737	± 30 Blue Mussels (Mytilus edulis)
Malmøysundet	59.875	10.756	± 30 Blue Mussels (Mytilus edulis)
Malmøysundet	59.875	10.756	± 30 Blue Mussels (Mytilus edulis)
Malmøysundet	59.875	10.756	± 30 Blue Mussels (Mytilus edulis)
Blakstad	59.820	10.483	± 30 Blue Mussels (Mytilus edulis)
Blakstad	59.820	10.483	± 30 Blue Mussels (Mytilus edulis)
Blakstad	59.820	10.483	± 30 Blue Mussels (Mytilus edulis)
Vollen	59.811	10.489	± 30 Blue Mussels (Mytilus edulis)
Vollen	59.811	10.489	± 30 Blue Mussels (Mytilus edulis)
Vollen	59.811	10.489	± 30 Blue Mussels (Mytilus edulis)

2.1.5.2 Herring gull eggs

Herring Gull (Larus argentatus) eggs were sampled at Søndre Skjælholmen (Nesodden municipality; 59.85317 N, 10.7281 E) in combination with the Urban fjord project. Egg were sampled from the same nests as described in the Urban fjord project report for 2020.

2.1.5.3 Fish liver

Cod liver samples were taken in combination with the Urban Fjord project in the Inner Oslo fjord at Alterdjupet and Gråøyrenna. In addition, two Whiting samples were collected in the Inner Oslo Fjord. All samples were collected by trawling at 80 - 100 m depth in the period from 27 September until 16 September 2020. The length of the sampled cod varied from 44 to 60 cm. The weights were in the range of 0.99 to 2.29 kg. Liver were removed from the cod for analysis. Liver weights were 41 to 218 grams. The Whiting samples consisted of two pooled individuals (30-35 cm, 234-366 grams) resulting in a total liver weight of 14 and 15 grams which were frozen until analysis.

2.1.6 Leisure boat harbour samples

Grab samples and sediment were taken on a sampling cruise in the Oslo fjord on the 24.08. and 25.08.2020. Samples were taken in leisure boat harbors on four locations where leisure boats are maintained and stored during the winter times. Samples were strategically taken in run off from service and boat cleaning areas or under jetties. The exact locations are given in Table 18 and are illustrated in Figure 11 and Figure 12.

Table 18. Sample location of the leisure boat harbour samples

Sample Location	Latitude	Longitude	Sample Type
Hovedøya	59.895	10.732	Soil
Hovedøya	59.895	10.731	Soil
Hovedøya	59.895	10.731	Sediment
Malmøysundet	59.874	10.756	Sediment
Malmøysundet	59.874	10.756	Soil
Malmøysundet	59.875	10.757	Soil
Blakstad	59.819	10.483	Soil
Blakstad	59.819	10.483	Soil
Vollen	59.810	10.485	Soil
Vollen	59.810	10.485	Sediment
Vollen	59.810	10.485	Sediment

Figure 11 Sample locations leisure boat harbor Hovedøya (soil, soil, and sediment). (Photo Bjørnar Andre Beylich, NIVA.)

Figure 12 Sample locations leisure boat harbour Vollen (soil, sediment, and sediment). (Photo Bjørnar Andre Beylich, NIVA.)

2.1.7 QA/QC

Field blanks were included for all air air, wipes, and dust samples and analyzed together with the real samples to control for possible contamination during sampling, transport, storage and analysis. No field blank samples were included for the other sample types like water, sediment, and biota. The field blanks included the filter unit for the vacuum cleaner or glass fiber filters used for wipes for dust sampling, Tenax tubes for air samples, empty deposition collector, and empty glass jars for granule samples. The field blanks were transported together with the real samples on each sampling day. Each dust filter was opened and inserted into the nozzle once, then repacked in double layer of alumina foil, two plastic bags and stored in freezer next to exposed samples until sample preparation. Similarly, the glass fiber filters were opened at the sites and re-packed as the wipe samples in foil and plastic bags. The Tenax tubes were opened and kept in the room during deployment of the real samples (1 min), then repacked and stored. All field blanks underwent the same analytical procedure as the real samples.

2.2 Chemical analysis

All described methods are based on NILU's and NIVA's in-house methods, which were specially developed, adapted, and optimized for the selected compounds. None of the used methods are accredited, but all analytical work was done according to accreditation requirements given in EN17025.

2.2.1 Volatile organic compounds

2.2.1.1 Air samples

The Tenax TA samples were analyzed using automated thermal desorption (TD) – trapping at minus 30℃ – followed by GC-MS analysis in Scan mode (Markes Unity thermal desorber and Agilent 7820A GC – 5977 B MSD). For all individual compounds calibration solutions with a concentration of 100 ng/µl were prepared. Those calibration solutions were injected directly into Tenax TA adsorption tubes with a stream of purified Nitrogen. The calibration tubes were run together with the real sampling tubes both before and after each batch of sampling tubes. Identification of the compounds was done in scan mode using both retention time and mass spectra library search. Quantification of each individual compound was done by integration of two compound specific ions.

2.2.1.2 Water samples

The dissolved gases were stripped off the water body with a stream of ultrafine bubbles of purified synthetic air. Using a flowrate of 80 mL/min directly onto Tenax TA adsorption tubes. The stripping volume was set to 5 times the water volume which should guarantee a complete stripping of gases other than air.

2.2.1.3 Granule samples

115 mL (by volume) of granule was incubated in a 10 ml glass vial together with a Tenax TA adsorption tube for seven days. The concentrations are reported in µg emitted per hour from 1 L (by volume) granule.

2.2.2 Semi-volatile organic compounds

2.2.2.1 Biota

To 1g of wet material in a glass tube was added surrogate standard followed by 1mL of Acetonitrile and 3mL of n-Hexane. The sample was vortexed, then sonicated for 30 min. Extraction continued for 24 h on a shaker, tubes were positioned horizontally for better mixing. After centrifugation, 200 uL of Hexane layer was taken for GC-MS analysis.

2.2.2.2 Soil/sediment/sludge

To 1g of wet material in a glass tube was added surrogate standard followed by 2mL of Acetonitrile and 2mL of n-Hexane. The sample was vortexed, then sonicated for 30 min. Extraction continued for 24 h on a shaker, tubes were positioned horizontally for better mixing. After centrifugation, 200 uL of Hexane layer was taken for GC-MS analysis.

2.2.2.3 Artificial turf granules

1g of rubber was added surrogate standard and ultrasonically extracted for 10min with 10mL of a (1/1) mixture of aceton/n-Hexane. 200uL was taken for analysis.

2.2.2.4 Water

A glass Oasis HLB solid phase extraction (SPE) column with 200mg material was precleaned with 5mL acetonitrile and conditioned with 5mL of Milli-Q water. Surrogate standard was added to each 50mL water sample before elution through the SPE column. The column was later washed with 5mL Milli-Q water and 5mL of 5% Acetonitrile in Milli-Q water and dried for 30min. Analytes were later eluted using 10mL acetonitrile. The acetonitrile eluent was concentrated to 200uL and transferred to an analytical glass vial for analysis.

2.2.2.5 Wipes

Wipes were dried in a cleanroom overnight. Wipes were then put in a 22mL glass and surrogate standard was added. 20mL of n-Hexane was then added and the sample sonicated for 10min before being pipetted into a new glass. 20mL of Acetone was then added with the same procedure. Extracts were concentrated under a stream of nitrogen gas and the concentrate was filtered through a Pasteur pipette packed with Kleenex to remove particulates and transferred to an analytical glass.

2.2.2.6 Bucket dust samplers

Glassfibre filters were washed with solvent, dried and put in a clean Buchner funnel. Pure Milli-Q water was added to the buckets before shaking and subsequent filtration. The filters with dust were then dried overnight. Following this they were placed in a 22mL glass and surrogate standard was added. The filters were ultrasonically extracted using 10 mL Acetone for 10min and the extract transferred to a new glass. This procedure was repeated using 10 mL n-Hexane. The extract was concentrated with a stream of nitrogen gas, then filtered and transferred to an analytical glass vial.

2.2.2.7 Instrumental analysis

The samples were analysed on GC Q Exactive HRAM Orbitrap instrument in a full-scan mode at mass-resolution 120000. The acquired files can be used for retrospective screening for other analytes of interest.

2.2.3 Dechloranes

2.2.3.1 Sample extraction and clean-up

Prior to extraction, the samples were added a mixture of isotope labelled PCB, SCCP (one single isomer) and dechloranes for quantification purposes. The water-, sediment-and biota-samples were extracted with organic solvents and concentrated under nitrogen flow, followed by a clean-up procedure combining a GPC separation and a silica column to remove lipids and other interferences prior to analysis.

2.2.3.2 Instrumental Analysis

Prior to analysis, all samples were concentrated to ~150 µL sample volume. The extracts were injected into an Agilent 7890N GC system coupled to an Agilent 7200 QtoF mass spectrometer operated in electron capture negative ionization mode (GC-ECNI-HRMS) and PCB-153 and the dechlorane compounds were quantified based on the use of internal standards.

2.2.4 Plasticizers

2.2.4.1 Soil/sediment/sludge

To 1g of wet material in a glass tube was added surrogate standard followed by 2mL of Acetonitrile and 2mL of n-Hexane. The sample was vortexed, then sonicated for 30 min. Extraction continued for 24 h on a shaker, tubes were positioned horizontally for better mixing. After centrifugation, 200 uL of Hexane layer was taken for GC-MS analysis.

2.2.4.2 Artificial turf granules

1g of rubber was added surrogate standard and ultrasonically extracted for 10min with 10mL of a (1/1) mixture of acetone/n-Hexane. 200uL was taken for analysis.

2.2.4.3 Water

A glass Oasis HLB solid phase extraction (SPE) column with 200mg material was precleaned with 5mL acetonitrile and conditioned with 5mL of Milli-Q water. 50mL of water sample was aliquoted out and surrogate standard added. The sample was then eluted through the SPE column. The column was later washed with 5mL Milli-Q water and 5mL of 5% Acetonitrile in Milli-Q water before being dried for 30min. The analytes were eluted using 10mL acetonitrile, and the acetonitrile was concentrated to 200uL and transferred to an analytical glass vial for analysis.

2.2.4.4 Wipes

Wipes were dried in the cleanroom overnight before being placed in a 22mL glass. Surrogate standard was added together with 20mL of n-Hexane before sonication for 10min. The solvent was then

pipetted into a new glass. 20mL of Acetone was then added with the same procedure. Extracts were concentrated under a stream of nitrogen gas and the concentrate was filtered through a Pasteur pipette packed with Kleenex to remove particulates and transferred to an analytical glass vial.

2.2.4.5 Bucket dust samplers

Glassfibre filters were washed with solvent and dried and put in a clean Buchner funnel. Milli-Q water was added to the buckets and then they were shaken. The water with particles was filtered and the filters with dust were then allowed to dry overnight. The filters were transferred to 22mL glass containers and surrogate standard added. The filters were ultrasonically extracted using 10 mL Acetone for 10min and the extract was transferred to a new glass. The procedure was repeated using 10 mL n-Hexane. The combined extract was concentrated with a stream of nitrogen gas and filtered and transferred to an analytical glass vial.

2.2.4.6 Instrumental analysis

The samples were analysed on GC Q Exactive HRAM Orbitrap instrument in a full-scan mode at mass-resolution 120000. The acquired files can be used for retrospective screening for other analytes of interest.

2.2.5 Secondary diphenyl amine compounds and analytically related compounds

2.2.5.1 Extraction

Freeze dried sediment and sludge (0,5-1 g) as well as dust (filter included) had internal standard (IS) added and were extracted with methanol+ethyl acetate (9+1) in an ultra sound bath for 60 min. Water samples (200 ml) were spiked with internal standards prior to concentration on a 200 mg HLB SPE column. The analytes were eluted from the SPE column with methanol+ethylacetat (9+1) and finally the extract was concentrated under nitrogen.

2.2.5.2 Instrumental Analysis

All samples were analyzed with HPLC-MSMS and HPLC-HRMS with electrospray ionizing (ESI). There were few isotope-labeled internal standards available.

2.2.6 Benzothiazoles

2.2.6.1 Extraction

Freeze dried sediment and sludge (0,5-1 g) as well as dust (filter included) had internal standard (IS) added and were extracted with methanol+ethyl acetate (9+1) in an ultra sound bath for 60 min. Water samples (200 ml) had IS added prior to concentration on a 200 mg HLB SPE column. The analytes were eluted of the SPE column with methanol+ethylacetat (9+1) and finally the extract was concentrated under nitrogen.

2.2.6.2 Instrumental Analysis

All samples were analyzed with HPLC-MSMS and HPLC-HRMS with electrospray ionizing (ESI). The use of high-resolution mass spectrometry in combination with traditional MSMS gives good sensitivity and excellent selectivity.

2.2.7 Phenolic compounds

2.2.7.1 Water samples

Water samples (150 ml) were spiked with isotopically labelled internal standards and extracted by solid phase extraction (SPE). Oasis SPE columns were conditioned with ethyl acetate, acetonitrile and with MilliQ water, the samples were then loaded, columns were washed with MQ water, MQ-water/acetonitrile (90:10), then dried under vacuum and analytes eluted with ethyl acetate/methanol (85:15). A final solvent-exchange to either toluene or methanol was then carried out ahead of analysis.

2.2.7.2 Sludge, soil, sediment, granule, wipe and dust samples

Sludge, soil and sediment samples (0.1g) were extracted with accelerated solvent extraction, while and further cleaned with SPE (see method for water description). Granule, wipes and dust sample were extracted using methanol and further cleaned with the SPE with the method similar to water

2.2.7.3 Instrumental analysis

Phenolic compounds were analysed using electrospray ionization with a ThermoScientific Vanquish UPLC coupled to Q Exactive Plus Orbitrap system operated in a negative electrospray mode (R=70.000 FWHM). Separation were achieved with the use of Waters HSS T3 column (1.8 µm, 150 x 3.0 mm) with a gradient of water and methanol used as a mobile phase. The data was acquired in the combination of full scan and data dependent acquisition (with inclusion lists) or using GC-MS with EI ionization on a Agilent 7200 GC-QTOF-HR-MS system.

2.2.8 Surfactants

2.2.8.1 Extraction

Freeze dried sediment and sludge (0,5-1 g) as well as dust (filter included) had internal standard (IS) added and were extracted with methanol+ethyl acetate (9+1) in an ultra sound bath for 60 min. Water samples (200 ml) had IS added prior to concentration on a 200 mg HLB SPE column. The analytes were eluted of the SPE column with methanol+ethylacetat (9+1) and finally the extract was concentrated under nitrogen.

2.2.8.2 Analysis

All samples were analyzed with HPLC-MSMS and HPLC-HRMS with electrospray ionizing (ESI).

2.2.9 pyr-GC-MS

2.2.9.1 Extraction

Sludge / sediment samples were freeze dried and pre-treated depending on the interferences present in the samples. Fragments of the rubber granules were analysed directly by pyr-GC-MS. For the analysis of car tire related compounds and additives, all samples were analysed without pre-treatment. For analysis of plastic polymers all organic material was decomposed by oxidation ((Hydrogen peroxide (H_2O_2) or potassium hydrate (KOH)) before pyr-GC-MS analysis. For these samples both the dissolved fraction and sediment (0.5 – 11 mg of dried material) were analysed.

pyr-GC-MS analysis were performed as both a double-shot and single-shot injection for all samples in triplicate. Different pyrolysis methods were used for different types of plastic and samples were run in several times. Using the double-shot methods, the first shot (thermal desorption) allowed the analysis of additives when the sample is gradually heated to 400 ° C. The second shot (flash pyrolysis) when the sample is flash heated (12s) to extreme high temperature (700 ° C) thermally desorbs road-related and rubber compounds (including SBR + BR + SBS) from car tires and asphalt. For specific plastic polymers a single-shot method was used as a replicate from the same sample by flash pyrolysis to 590 °C).

2.3 Quality assurance and measurement uncertainties

Each of the many steps involved in the process of performing environmental screening studies for contaminants of emerging concern will have an impact on the overall uncertainty of the final results. This uncertainty starts with the design of the sampling regime and is compounded through the entire process to storage of samples, chemical analysis and data treatment. In addition, authentic samples of target analytes to prepare calibration solutions (standards) were not available for all compounds. Moreover, several target analytes are incompletely defined mixtures of isomers or congeners. Furthermore, isotope labelled internal standards, which often are used to control the loss of analytes during extraction, clean-up and instrumental analysis, were available for only a few analytes. When no isotope labelled internal standards were available, several samples were spiked with a given amount of analyte to evaluate recovery and assure detection.

Although it is difficult to estimate the absolute uncertainty for all steps in the process, we are confident that uncertainty in the results from screening studies are higher than that of routine monitoring of PCBs or other legacy POPs. While the total measurement uncertainty for an established legacy contaminant as PCBs is approximately 25 to 30 %, we would estimate that for screening compounds this value would be in the order of 40 to 50 % for new emerging compounds as measured in this report.

Each sample group was analysed in batches with about 5-12 samples, with field or laboratory blanks following each batch analyses. Some of the contaminants were found in relative high concentrations in the blind (blank) samples, such as some plasticizers and phenolic compounds. These specific compounds, which are marked with an asterisk (*) in the detection frequency table of chapter 3.1, show a significant higher LoD resulting in lower detection frequency. In addition, uncertainty are assumed to be higher compared to other compounds.

In the tables of chapter 3 the range, average, and detection frequency are given. These values give only a first indication of the real situation and should not be used without critical evaluation for time trend or spatial trend studies, as the number of samples is limited and only give a snapshot for a small area. In the case of non-detects half of the limit of detection (LoD/2) is used, when calculating the average. With decreasing detection frequencies, the uncertainty of the calculated average concentrations will increase consequently.

3 Results and discussion

3.1 Detection frequency for contaminants

In this study over 100 different compounds with an array of physiochemical properties were measured in environmental samples. These samples included indoor air and dust samples, surface water, municipal wastewater, and marine sediments and biota. A complete data table is included in the appendix and a detailed presentation of selected results is given in the subsequent chapters.

Table 19 and Table 20 present the frequency of detection of all compounds in all sample types. Detection frequency is the percentage of samples in which a compound was detected relative to the total number of analysed samples. It should be noted that, as always, the results are dependent on detection limits for each compound and the amount of sample available. A non-detect or zero in this table is not a guarantee that the compound is not present, but instead that the compound was not detectable with the analytical methods applied.

Table 19: Detection frequency of volatile organic compounds in all samples. Detection frequency is given by the number of detects divided by the total number of measured samples given in percent.

Compound group	Compound	Alna river Surface water	Road tunnel Runoff water	Vehicle wash Air	Cars Air	Artificial turf Granules	Artificial turf Air	Nonres. Building Air	Resid. Building Air	New building Air
VOC	**HFE-7500**	0	0	0	0	0	0	0	0	0
	TFE	0	0	0	0	0	0	0	10	0
	Benzene	100	44	100	100	100	100	100	100	100
	Toluene	100	89	100	100	100	100	100	100	100
	m+p-Xylene	100	67	100	100	100	100	100	100	100
	o-Xylene	90	67	100	100	90	100	100	100	100
	α-Pinene	90	78	100	100	90	100	100	100	100
	Styrene	0	89	100	100	100	100	100	100	100
	β-Pinene	90	67	100	100	90	100	100	100	100
	M3T	90	0	0	8	0	0	20	10	0
	135-TMBz	90	67	100	100	90	100	100	100	100
	3-Carene	90	67	100	100	90	100	100	100	100
	124-TMBz	90	67	100	100	90	100	100	100	100
	Limonene	90	67	100	100	90	88	100	100	100
	p-Cymene	80	67	100	100	90	100	100	100	100
	123-TMBz	90	56	100	100	90	100	100	100	100
	Linalyl formate	0	0	0	0	0	0	0	0	0
	Terpineol	0	0	50	69	40	63	70	90	71
	Lilial	50	44	100	69	60	50	100	40	57
	DCBTC	0	0	0	0	0	0	0	0	0
	HxDcOH	0	0	0	0	0	0	0	0	0
	AcCedrene	0	0	33	0	0	0	0	10	0

Table 20: Detection frequency of all compounds except volatiles in all samples. Detection frequency is given by the number of detects divided by the total number of samples (%, na = not analysed).

Compound group	Compound	STP Effluent	STP – Sludge	Alna river – Surface water	Marina – Soil/sediment	Oslofjord – Fish liver	Oslofjord – Gull egg	Marina . Blue mussel	Road tunnel – Runoff	Road tunnel – Sand trap	Vehicle wash – Wipes	Artificial turf – Granules	Artificial turf – Dust	Nonres. Building – Dust	Resid. Building – Dust	New building -Dust/Wipes	Cars – Wipes
SVOC	**DET**	0	0	0	0	na	na	0	0	0	0	0	0	11	0	0	0
	DIPBP	0	0	0	0	na	na	0	0	11	0	0	0	0	0	0	0
	TIPBP	0	0	0	0	na	na	0	0	0	0	0	0	0	0	0	0
	BT	0	0	0	10	na	na	0	0	0	0	20	0	33	10	0	0
	isoTAC	90	0	100	0	na	na	0	100	0	60	10	14	78	70	71	100
	TAC	90	0	100	0	na	na	0	89	0	0	0	0	0	0	14	18
	CTC	0	100	0	0	na	na	0	0	0	0	0	0	0	0	0	0
	DBP	0	0	0	0	na	na	0	0	0	0	0	0	0	0	0	0
	TBNPA	0	0	0	0	na	na	0	22	0	0	10	0	11	0	0	0
	CEA	0	0	0	0	na	na	0	0	0	0	0	0	0	0	0	0
Dechloranes	DBAldrin	na	0	na	0	0	0	na	na	0	0	na	0	0	0	0	0
	Dec602	na	0	na	10	100	100	na	na	0	0	na	0	0	0	0	0
	Dec603	na	0	na	0	0	33	na	na	0	0	na	0	0	0	0	0
	Dec604	na	0	na	0	0	0	na	na	0	0	na	0	0	0	0	0
	Dec601	na	0	na	0	0	0	na	na	0	0	na	0	0	0	0	0
	DPsyn	na	100	na	50	0	67	na	na	67	67	na	0	56	20	14	27
	DPanti	na	100	na	100	100	100	na	na	100	83	na	29	100	100	57	36
	13DPMA	na	0	na	0	0	0	na	na	0	0	na	0	0	0	0	0
	15DPMA	na	0	na	0	0	0	na	na	0	0	na	0	0	0	0	0
	CDeneP	na	0	na	0	0	0	na	na	0	0	na	0	0	0	0	0
Plasticizer	**ATBC**	0	na	0	20	na	na	na	0	na	50	40	0	89	100	100	36
	NPGD[*)]	0	na	0	0	na	na	na	0	na	0	0	0	0	10	0	0
	DDcP	0	na	0	0	na	na	na	0	na	50	0	0	56	30	0	55
	TOTM	0	na	0	20	na	na	na	0	na	100	0	14	100	100	100	100
	DMP	0	na	0	0	na	na	na	0	na	0	0	0	0	0	0	0
	DEP	20	na	0	20	na	na	na	11	na	0	0	0	0	0	0	0
	DiBP[*)]	50	na	0	10	na	na	na	22	na	0	40	0	11	20	0	0
	DnBP[*)]	90	na	10	30	na	na	na	11	na	17	30	0	44	30	29	0
	BMEP	20	na	0	0	na	na	na	33	na	0	0	0	0	0	14	0
	DMPP	0	na	0	0	na	na	na	0	na	0	0	0	11	10	29	0
	BEEP	0	na	0	0	na	na	na	0	na	0	0	0	11	0	0	0
	DPP	0	na	0	0	na	na	na	0	na	0	0	0	0	0	0	0
	DHxP	0	na	0	0	na	na	na	0	na	0	0	0	0	0	0	0
	BBP	10	na	0	10	na	na	na	0	na	0	0	0	89	70	29	9
	DBOEP	0	na	0	0	na	na	na	0	na	0	0	0	11	0	0	0

Compound group	Compound	STP Effluent	STP – Sludge	Alna river – Surface water	Marina – Soil/sediment	Oslofjord – Fish liver	Oslofjord – Gull egg	Marina . Blue mussel	Road tunnel – Runoff	Road tunnel – Sand trap	Vehicle wash – Wipes	Artificial turf – Granules	Artificial turf – Dust	Nonres. Building – Dust	Resid. Building – Dust	New building -Dust/Wipes	Cars – Wipes
	DEHP	70	na	30	40	na	na	na	67	na	100	80	29	100	100	100	91
	DCHP	0	na	0	70	na	na	na	0	na	0	0	0	33	40	86	18
	DOP	0	na	0	0	na	na	na	0	na	0	0	0	0	0	0	0
	DiNP*)	70	na	10	0	na	na	na	67	na	100	70	14	100	100	100	82
	DNP	0	na	0	0	na	na	na	0	na	50	0	0	0	20	0	27
	DiDP	90	na	90	0	na	na	na	100	na	83	0	0	100	100	100	91
	TEP	30	na	90	0	na	na	na	11	na	17	20	0	0	0	43	0
	TPP	0	na	0	0	na	na	na	0	na	0	0	0	0	0	0	0
	TNBP*)	90	na	70	0	na	na	na	11	na	0	10	0	11	0	57	0
	TCEP	0	na	10	0	na	na	na	11	na	67	10	0	33	40	29	27
	TCIPP	90	na	100	0	na	na	na	22	na	67	30	0	22	40	100	36
	TBOEP	50	na	10	0	na	na	na	0	na	50	0	0	100	80	57	91
	TDCIPP*)	50	na	40	0	na	na	na	0	na	50	0	0	100	80	71	91
	TPHP	50	na	10	0	na	na	na	0	na	33	10	0	100	80	100	91
	EHDP	0	na	0	60	na	na	na	0	na	67	20	0	100	80	86	73
	TEHP	0	na	0	0	na	na	na	56	na	83	70	0	78	80	29	64
	2IPPDPP	0	na	0	10	na	na	na	0	na	0	10	0	11	0	14	0
	TOTP*)	0	na	0	0	na	na	na	0	na	0	0	0	0	0	0	0
	TMTP	0	na	0	60	na	na	na	0	na	0	0	0	0	0	0	27
	4IPPDPP	0	na	0	10	na	na	na	0	na	0	0	0	0	0	0	0
	TPTP	0	na	0	0	na	na	na	0	na	0	0	0	0	0	0	9
	T2IPPP	0	na	0	10	na	na	na	0	na	0	0	0	0	0	0	0
	T35DMPP	0	na	0	0	na	na	na	0	na	0	0	0	0	0	0	0
	B4IPPPP	0	na	0	0	na	na	na	0	na	0	0	0	0	0	0	0
	TTBPP	0	na	0	0	na	na	na	0	na	0	0	0	0	0	0	0
	V6	0	na	0	0	na	na	na	0	na	50	0	0	89	50	14	9
	IDDPP	10	na	0	20	na	na	na	0	na	67	10	0	100	100	71	91
SDPA	**PhDPA**	0	0	0	0	0	0	na	11	0	0	40	0	0	0	0	0
	TeMeDPA	0	0	0	0	0	0	na	11	0	0	0	0	0	0	0	0
	tBuDPA	0	100	0	10	0	0	na	100	100	17	60	0	11	10	0	18
	DiMeFluDPA	0	0	0	0	0	0	na	11	0	0	0	0	0	0	0	0
	BrPhDPA	0	0	0	0	0	0	na	0	0	0	0	0	0	0	0	0
	PhDiMeFluDPA	0	0	0	0	0	0	na	0	0	0	0	0	0	0	0	0
	iPrtBuDPA	0	0	0	0	0	0	na	0	0	0	0	0	0	0	0	0
	Naugalube	0	0	0	0	0	0	na	0	0	0	0	0	0	0	0	0
	DtBuDPA	0	100	0	20	0	0	na	100	100	17	60	0	11	0	0	18
	BuDiMeFluDPA	0	0	0	0	0	0	na	0	0	0	0	0	0	0	0	0

Compound group	Compound	STP Effluent	STP – Sludge	Alna river – Surface water	Marina – Soil/sediment	Oslofjord – Fish liver	Oslofjord – Gull egg	Marina . Blue mussel	Road tunnel – Runoff	Road tunnel – Sand trap	Vehicle wash – Wipes	Artificial turf – Granules	Artificial turf – Dust	Nonres. Building – Dust	Resid. Building – Dust	New building -Dust/Wipes	Cars – Wipes
SDPA	**iPrcHxDPA**	0	0	0	0	0	0	na	0	0	0	0	0	0	0	0	0
	DiDiMeFluorenyl	0	0	0	0	0	0	na	0	0	0	0	0	0	0	0	0
	diAMS	0	100	0	10	0	0	na	100	100	17	50	0	44	10	0	0
	DiHxDPA	0	0	0	0	0	0	na	0	0	0	0	0	0	0	0	0
	DitOcDPA	0	100	0	100	0	0	na	100	100	50	60	0	67	20	0	18
	DAT	0	0	0	0	0	0	na	0	0	0	0	0	0	0	0	0
	MDA	0	100	0	0	0	0	na	0	0	0	40	0	0	0	0	18
	DBM	0	0	0	0	0	0	na	0	100	0	0	0	56	0	0	18
	Iodocarb	0	0	0	0	0	0	na	11	0	0	0	0	0	0	57	0
	VSU	0	0	0	0	0	0	na	33	0	0	0	0	11	0	14	0
	Solvent Y 124	0	0	0	0	0	0	na	0	0	0	0	0	0	0	14	0
	MFPDE	0	0	0	0	0	0	na	11	0	0	0	0	0	0	0	0
	Tinopal	100	100	0	0	0	0	na	0	0	0	0	0	22	10	14	0
	Iscotrizinol	0	100	0	0	0	0	na	0	0	17	0	0	67	40	57	73
	6PPD Q	50	0	10	40	0	0	na	100	100	50	100	57	0	0	0	18
BTZ	BTZ*)	0	0	0	0	0	0	na	0	67	0	60	0	0	0	0	0
	MBTZ*)	0	0	0	0	0	0	na	0	11	0	0	0	0	0	0	18
	ABTZ	100	50	90	20	0	0	na	100	67	17	70	0	0	0	0	0
	MTBTZ	0	0	0	0	0	0	na	100	100	0	100	0	11	10	0	0
	TBBS	0	0	0	0	0	0	na	33	0	0	70	0	0	0	0	0
	PBTZ	0	50	0	10	0	0	na	100	100	17	70	0	0	0	0	9
	CBS	0	0	0	0	0	0	na	44	0	0	70	0	0	0	0	0
	HOBT	0	100	10	20	0	0	na	100	100	50	80	0	67	40	0	36
	BBIT	0	0	0	0	0	0	na	0	0	0	0	0	22	10	0	0
	MTBS	0	0	0	0	0	0	na	0	0	17	0	0	0	0	0	0
	UV-350	0	0	10	0	0	0	na	0	0	0	0	0	0	0	0	0
	Altax	0	0	0	0	0	0	na	0	0	0	80	0	11	0	0	0
	DTPB	0	0	0	0	0	0	na	0	0	0	30	0	0	0	0	0
	BTSA	90	50	40	30	0	0	na	100	100	83	70	57	67	40	86	100
	MBT	0	90	0	60	0	0	na	100	100	83	70	100	33	0	0	27
Phenols	**BHT**	70	na	20	50	na	na	na	78	na	33	60	0	100	100	71	55
	BHT-CHO*)	0	na	0	30	na	na	na	22	na	17	90	0	44	90	43	64
	BHT-COOH	60	na	70	0	na	na	na	100	na	0	70	0	11	0	0	36
	BHT-OH	60	na	0	10	na	na	na	11	na	0	10	0	0	0	0	0
	BHT-Q*)	0	na	0	80	na	na	na	56	na	0	30	14	78	60	57	82
	DCP	0	na	0	40	na	na	na	0	na	0	0	0	44	20	0	0

Compound group	Compound	STP Effluent	STP – Sludge	Alna river – Surface water	Marina – Soil/sediment	Oslofjord – Fish liver	Oslofjord – Gull egg	Marina . Blue mussel	Road tunnel – Runoff	Road tunnel – Sand trap	Vehicle wash – Wipes	Artificial turf – Granules	Artificial turf – Dust	Nonres. Building – Dust	Resid. Building – Dust	New building -Dust/Wipes	Cars – Wipes
	TTBP	0	na	0	30	na	na	na	67	na	17	20	0	89	30	43	18
	TBBC	0	na	0	0	na	na	na	0	na	0	0	0	22	0	0	9
	VANOX	0	na	0	10	na	na	na	0	na	0	10	43	89	100	71	91
	PTBP	0	na	10	50	na	na	na	100	na	0	60	0	0	0	0	0
	24-DTBP[*)]	0	na	10	40	na	na	na	67	na	17	80	0	22	40	29	45
	DtAP	0	na	20	20	na	na	na	0	na	0	30	0	11	10	14	0
	D8(HPS)	10	na	0	10	na	na	na	100	na	33	0	0	100	70	29	64
	BHT-quinol	90	na	70	0	na	na	na	0	na	17	70	0	11	10	0	0
	3-BHA	0	na	0	0	na	na	na	0	na	0	0	0	0	0	0	0
	TBHQ	0	na	0	0	na	na	na	0	na	0	10	0	0	10	0	0
	EP	70	na	10	0	na	na	na	22	na	50	80	0	89	100	71	73
	MP	0	na	0	20	na	na	na	0	na	0	30	0	67	70	14	18
	PP	10	na	0	0	na	na	na	0	na	0	10	0	44	100	0	9
	iPP	10	na	0	0	na	na	na	0	na	0	0	0	0	0	0	0
	BuP	0	na	0	0	na	na	na	0	na	0	10	0	78	70	14	36
	iBuP	0	na	0	0	na	na	na	0	na	0	0	0	0	10	0	0
	BenzP	10	na	0	0	na	na	na	0	na	17	10	0	11	0	29	0
	MB-DTBP	0	na	20	50	na	na	na	78	na	17	90	0	33	10	29	55
	MB-ETBP	0	na	0	0	na	na	na	0	na	0	40	0	0	0	0	0
	Fenozan[*)]	0	na	0	20	na	na	na	0	na	0	70	0	0	0	0	27
	BHA	0	na	0	0	na	na	na	0	na	0	0	0	0	0	0	0
	MB-MTBP	0	na	0	0	na	na	na	0	na	0	0	0	0	0	0	0
	DTAHQ	80	na	0	20	na	na	na	33	na	0	40	0	56	90	43	27
	26-DTBP	0	na	0	30	na	na	na	67	na	0	70	14	67	100	57	91
	DTDA-oxide	0	0	0	0	na	na	0	0	0	67	0	0	67	20	71	18
SURF	**DDDA-oxide**	0	0	0	0	na	na	0	0	0	50	0	0	67	40	71	36
	DDDA	0	70	0	10	na	na	0	0	0	33	0	0	44	0	14	27
	DHDA[*)]	0	100	0	0	na	na	0	0	0	0	0	0	0	0	0	0
	DTDA	0	100	0	0	na	na	0	0	0	33	0	0	0	0	0	0
	DDOA[*)]	0	0	0	0	na	na	0	0	0	0	0	0	0	0	0	0
	DDA-oxide	0	0	0	0	na	na	0	0	0	17	0	0	0	0	14	0
	DOA	0	0	0	0	na	na	0	0	67	0	0	0	0	0	0	0
	DODA[*)]	0	0	0	0	na	na	0	0	0	0	0	0	0	0	0	0

[*)]: Compounds marked with asterisk have for some or all samples an elevated LoD, which might reduce the detection frequency shown in this table.

3.2 Volatile organic compounds

The concentration range, average, and detection frequency for the detected volatile organic compounds (VOCs) are summarized in Table 21 and Table 22. The limit of detection (LoD) for VOCs not found in any sample type are given in the complete data table in the excel attachment.

3.2.1 Water samples

Table 21: Concentration range, average, and detection frequency of VOCs in surface water and road tunnel wash water.

	Alna river Surface water	Road tunnel Wash water
	µg/L	**µg/L**
Benzene	0,08 – 0,75 0,50 100 %	<0,04 – 19 8,1 44 %
Toluene	0,05 – 120 13 100 %	<0,04 – 100 46 89 %
m+p-Xylene	0,02 – 2,4 0,39 100 %	<0,04 – 33 13 67 %
o-Xylene	<0,04 – 1,2 0,21 90 %	<0,06 – 23 9,4 67 %
α-Pinene	<0,02 – 0,19 0,11 90 %	<0,06 – 300 105 78 %
Styrene	<0,02 - <0,02 0 %	<0,04 – 57 25 89 %
β-Pinene	<0,02 – 0,09 0,03 90 %	<0,04 – 49 15 67 %
M3T	<0,02 – 0,37 0,20 90 %	<0,04 - <0,04 0 %
135-TMBz	<0,02 – 0,45 0,09 90 %	<0,02 – 2,8 1,2 67 %
3-Carene	<0,02 – 0,12 0,05 90 %	<0,06 – 210 88 67 %
124-TMBz	<0,02 – 0,39 0,09 90 %	<0,02 – 6,7 3,2 67 %
Limonene	<0,04 – 4,5 0,81 90 %	<0,1 – 40 15 67 %

	Alna river Surface water	Road tunnel Wash water
	µg/L	**µg/L**
p-Cymene	<0,02 – 0,08 0,05 80 %	<0,02 – 16 5,2 67 %
123-TMBz	<0,02 – 0,24 0,05 90 %	<0,02 – 2,3 0,93 56 %
Lilial	<0,02 – 0,13 0,04 50 %	<0,06 – 9,6 1,5 44 %

Average: For the non-detects LoD/2 was used, when calculating the average.

The fragrance compounds pinenes, 3-carene, p-cymene, terpineol, and lilial were found with rather low concentrations and little variation in surface water samples. However, the aromatic VOCs benzene, toluene, xylenes, and trimethylbenzenes showed much higher concentration and large variation between minimum and maximum concentration, which might be related to transport episodes caused by storm rain events. In addition, in some cases the measured concentrations are close to or above the lowest predicted no effect concentration (lowest PNEC) as shown in Table 47 in chapter 5 and further follow-up should be considered.

The compound 1,1,1,3,5,5,5-heptamethyl-3- [(trimethylsilyl)oxy] trisiloxane (M3T) with the commercial name methyl trimethicone is used in similar applications as the more known siloxane D5. It was found in 90 % of all surface water samples from Alna river. The average concentration in these samples were 0,20 µg/L, whereas the D5 concentrations measured in 2014 and 2015 were one order of magnitude higher ranging from 5 to 12 ng/l (Vannmiljø 2021). However, the measured M3T concentrations are only a factor of five lower than the PNEC listed in the NORMAN NDS for the freshwater aquatic life (NORMAN 2021) (see also Table 47 in chapter 5). In addition, this compound is under PBT assessment by ECHA (ECHA 2021). M3T is of environmental concern and qualifies for a closer follow up to better characterize the environmental risk of this compound.

The other compounds were found only in low concentrations or not at all in surface water samples from Alna river. However, the first surface water sample taken at Breivoll with a sum concentration for the aromatics (sum BTX) ~ 120 µg/L exceeds the odour threshold given in the Norwegian drinking water directive (FHI 2021) and further follow-up should be considered. In addition, the detection of a long range of halogenated solvents in some surface water samples are of concern, since some of these compounds are known to be cancerogenic, if these findings are related to a continuous emission source or if this was only a single accidental event was not possible to answer.

During analysis of the compounds selected for this study, some unexpected but very dominating signals were observed and identified as shown in Figure 13.

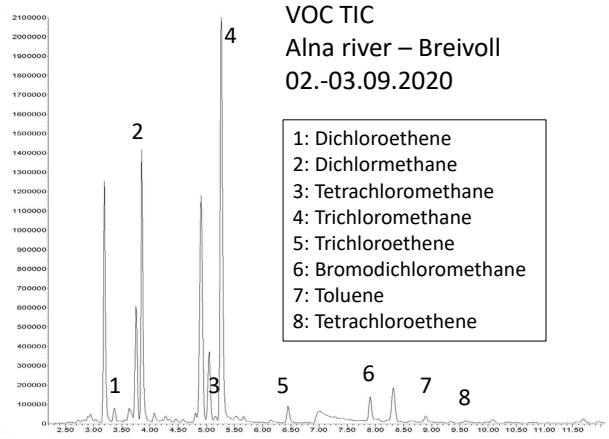


Figure 13: Total ion chromatogram of a surface water sample showing the most dominating compounds

In several of the water samples taken at Breivoll in September 2020, halogenated compounds were among the dominating compounds detected in these samples. The same compounds were also found in samples from Kværner, but less dominating. Since these compounds were not selected for this study and in fact were not expected at all, none of these compounds were included in the calibration procedure. The corresponding concentration could therefore only be roughly estimated. Trichloromethane (TCM: ~ 40 µg/L) and dichloromethane (DCM: ~ 14 µg/L) were found with highest concentration in the Breivoll sample from 02.-03.09.2020, but also trichloroethene (TCE), tetrachloro ethene (PCE) and dichloroethene as well as tetrachloromethane (CCl4) are among the compounds detected. Even dichlorobromomethane, which is possibly carcinogenic compound, was among the 10 most dominating gases in the samples with an estimated concentration of 3 µg/L.

Leakage of chlorinated solvents into surface water system is very unlikely as some of the measured compounds were hardly used as solvents and are not on the market at all. Most of those compounds can be produced by chlorination of organic matter dissolved in water, like in disinfection processes based on chlorination techniques (Richardson, Plewa et al. 2007, Li, Liu et al. 2019, Li, Song et al. 2021). The TCM concentration of ~ 40 µg/L is very high compared to what is measured in surface water from other European cities. The highest value for TCM (4,9 µg/L) in surface water reported to the NORMAN NDS is from the Rotterdam area in the Netherlands is nearly one order of magnitude lower. Consequently, these findings are of high concern and it should be investigated, if this was only an accidental short-term episode, maybe due to COVID-19 related disinfection needs, or if this is an active emission source. If this is still an active source, the source could be localized by taking a series of samples up-streams the Breivoll sampling site.

3.2.2 Granule and air samples

Table 22: Concentration range, average, and detection frequency of VOCs emission from granules and air.

	Vehicle wash Air	Cars Air	Artificial turf Granules	Artificial turf Air	New building Air	Nonres. Building Air	Resid. Building Air
	µg/m3	**µg/m3**	**µg/h*L *)**	**µg/m3**	**µg/m3**	**µg/m3**	**µg/m3**
Benzene	1,2 – 15 5,0 100 %	0,04 – 11 3,3 100 %	1,5 – 57 22 100 %	0,38 – 1,7 0,88 100 %	0,72 – 1,3 1,0 100 %	0,59 – 1,3 1,0 100 %	0,47 – 1,6 0,98 100 %
Toluene	5,1 – 58 19 100 %	2,4 – 94 16 100 %	0,53 – 110 47 100 %	0,71 – 7,4 3,1 100 %	1,4 – 20 8,2 100 %	3,3 – 11 6,4 100 %	2,3 – 17 5,6 100 %
m+p-Xylene	0,89 – 49 14 100 %	0,28 – 85 15 100 %	0,25 – 160 32 100 %	0,23 – 6,4 1,7 100 %	1,2 – 7,7 5,0 100 %	0,44 – 42 7,5 100 %	1,1 – 21 4,4 100 %
o-Xylene	0,44 – 29 7,2 100 %	0,14 – 31 6,0 100 %	<0,1 – 99 21 90 %	0,17 – 4,6 0,99 100 %	1 – 22 6,6 100 %	0,24 – 18 4,4 100 %	0,67 – 11 3,3 100 %
α-Pinene	0,75 – 3,5 1,9 100 %	0,55 – 24 4,0 100 %	<0,1 – 300 88 90 %	0,96 – 11 3,3 100 %	6,9 – 530 126 100 %	0,69 – 290 42 100 %	6,9 – 150 43 100 %
Styrene	0,29 – 3,8 2,0 100 %	0,14 – 17 2,5 100 %	<0,3 – 150 39 90 %	0,05 – 0,43 0,16 100 %	0,28 – 3,2 1,5 100 %	0,08 – 1,1 0,58 100 %	0,43 – 1,8 0,99 100 %
β-Pinene	0,11 – 4,1 0,96 100 %	0,13 – 8,4 1,1 100 %	<0 – 50 10 90 %	0,01 – 1,3 0,44 100 %	0,78 – 41 9,8 100 %	0,16 – 16 2,6 100 %	0,74 – 19 5,7 100 %
M3T	<0,02 - <0,02 0 %	<0,02 – 0,12 0,02 8 %	<0,1 - <0,1 0 %	<0,02 - <0,02 0 %	<0,02 - <0,02 0 %	<0,02 – 2,3 0,32 20 %	<0,02 – 23 2,3 10 %
135-TMBz	0,14 – 220 39 100 %	0,06 – 100 12 100 %	<0 – 14 4,4 90 %	0,09 – 0,45 0,20 100 %	0,07 – 0,87 0,42 100 %	0,1 – 0,48 0,26 100 %	0,1 – 2,7 0,51 100 %
3-Carene	0,23 – 4,5 1,3 100 %	0,22 – 5,5 1,3 100 %	<0 – 830 103 90 %	0,27 – 3 0,99 100 %	3,5 – 290 66 100 %	0,21 – 91 15 100 %	3,8 – 92 23 100 %
124-TMBz	0,63 – 870 154 100 %	0,19 – 420 54 100 %	<0,1 – 55 15 90 %	0,18 – 1,7 0,62 100 %	0,1 – 3,2 1,2 100 %	0,39 – 2 0,97 100 %	0,31 – 9,3 1,7 100 %
Limonene	0,6 – 71 21 100 %	0,3 – 100 17 100 %	<0 – 100 25 90 %	<0,04 – 2,6 0,64 88 %	0,35 – 50 16 100 %	0,17 – 19 4,2 100 %	2 – 74 25 100 %
p-Cymene	0,2 – 230 40 100 %	0,06 – 93 9,7 100 %	<0 – 120 16 90 %	0,09 – 0,4 0,17 100 %	0,47 – 21 5,7 100 %	0,15 – 5,3 1,0 100 %	0,56 – 8,6 2,8 100 %
123-TMBz	0,35 – 760 132 100 %	0,12 – 280 33 100 %	<0,1 – 16 5,2 90 %	0,08 – 0,48 0,23 100 %	0,06 – 1 0,49 100 %	0,19 – 0,68 0,39 100 %	0,02 – 2,2 0,47 100 %

	Vehicle wash Air	Cars Air	Artificial turf Granules	Artificial turf Air	New building Air	Nonres. Building Air	Resid. Building Air
	µg/m3	**µg/m3**	**µg/h*L *)**	**µg/m3**	**µg/m3**	**µg/m3**	**µg/m3**
Terpineol	<0,02 – 0,93 0,25 50 %	<0,02 – 4,2 0,63 69 %	<0,1 – 36 5,8 40 %	<0,02 – 0,31 0,10 63 %	<0,02 – 2,1 0,86 71 %	<0,02 – 2,7 0,41 70 %	<0,02 – 1,5 0,44 90 %
Lilial	0,02 – 0,12 0,07 100 %	<0,02 – 0,46 0,10 69 %	<0,1 – 6 1,2 60 %	<0,02 – 0,04 0,02 50 %	<0,02 – 0,27 0,10 57 %	0,02 – 0,14 0,06 100 %	<0,02 – 0,3 0,08 40 %
DCBTC	<0,06 - <0,06 0 %	<0,06 - <0,06 0 %	<0,12 - <0,12 0 %	<0,06 - <0,06 0 %	<0,06 - <0,06 0 %	<0,04 - <0,06 0 %	<0,04 - <0,06 0 %
AcCedrene	<0,02 – 1,6 0,31 33 %	<0,02 - <0,02 0 %	<0,4 - <0,4 0 %	<0,02 - <0,02 0 %	<0,02 - <0,02 0 %	<0,02 - <0,02 0 %	<0,02 – 0,23 0,03 10 %

Average: For the non-detects LoD/2 was used, when calculating the average.

*): The concentrations are reported in µg emitted per hour from 1 L (by volume) granule (µg/h*L) (see chapter 2.2.1.3).

α-Pinene, 3-Carene, and p-Cymene, which are used as solvents and fragrances in cleaning products, were detected in all samples and with high concentrations. Terpineol and Lilial were found with lower frequency and at lower concentrations. The siloxane M3T was frequently detected in sewage effluent but only occasionally in other source-related samples, i.e. indoor air samples and road tunnel wash water. The detected concentrations of M3T in these samples were lower compared to the above-mentioned compounds. Only three indoor related samples had detectable levels of M3T; one public building (a kindergarten), one residential site and in one car after being washed. The lack of detection in source-related samples makes it difficult to assess soures for M3T to surface water.

Acetylcedrene (AcCedrene) was only found in a few air samples from vehicle wash facilities and one residential building. 2,2,2-Trifluoroethanol (TFE) was only found in one air sample from a residential building with a concentration of 3,3 µg/m^3. 3-Ethoxyperfluoro(2-methylhexane) (HFE-7500), Linalyl formate, and 2-Hexyl-1-decanol (HxDcOH) could not be detected in any of the selected samples.

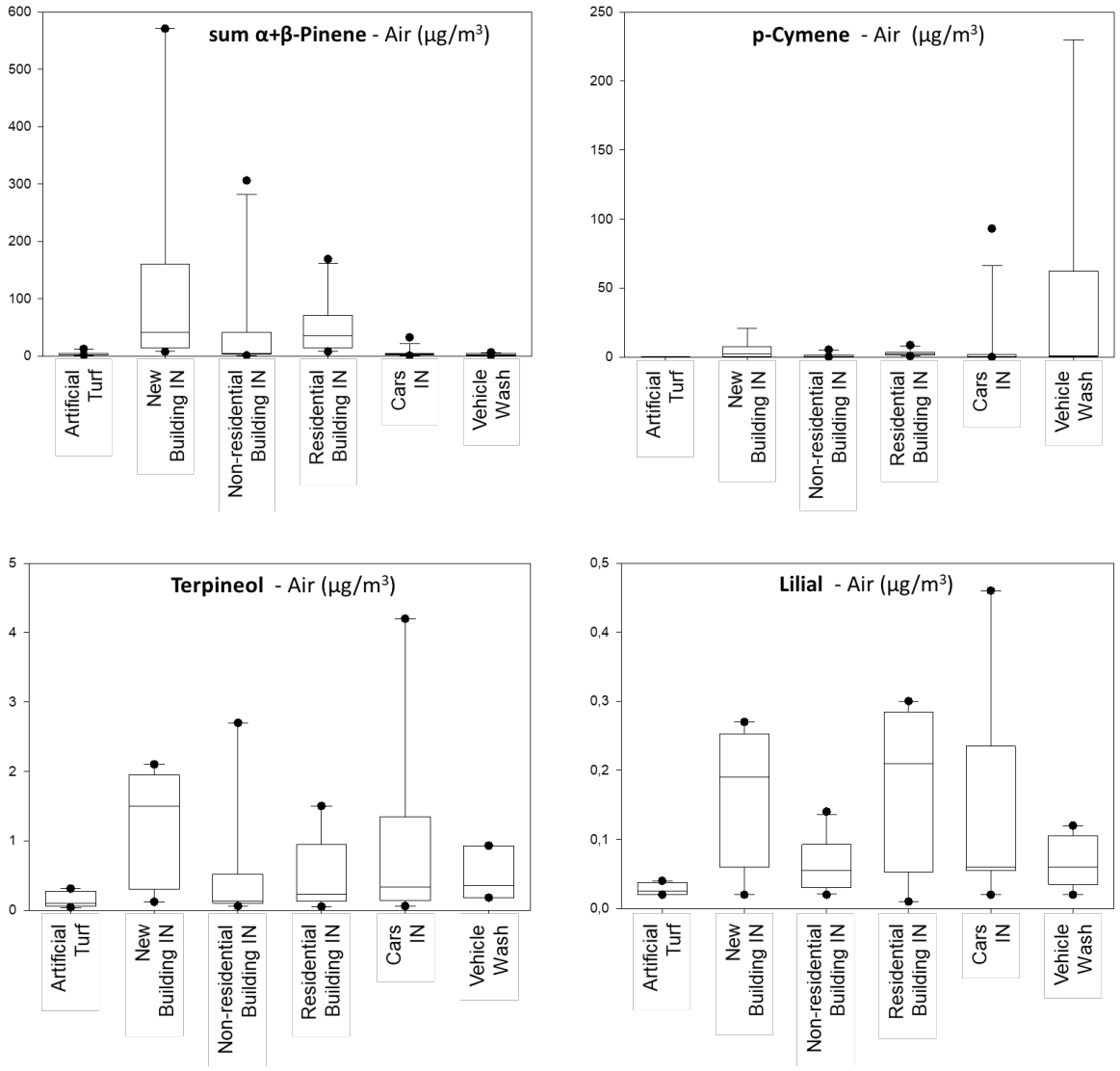


Figure 14: Box-plots of measured concentrations of four VOCs (µg/m³) with high detection in air at indoor sites, artificial turfs and vehicle wash facilities. The box-plots represents a range from 25-75% confidence interval with the center line representing the median concentrations and the error bars the outliers, respectively.

At the three residential buildings newly renovated or under construction, elevated concentrations of α- and β-pinene, p-cymene, and terpineol were measured. All at about ten times higher than at the newly constructed/renovated non-residential buildings and the existing residential and non-residential buildings. One non-residential building (a storage of furniture) also had elevated concentrations of these four VOCs. For Lilial there was no difference between new and existing residential buildings, but the concentrations at the non-residential sites were lower than at the residential sites. The highest concentrations of α- and β-pinene were measured at a residential site under construction. This site was intentionally build using only wooden materials and steel and avoiding plastic (synthetic) materials (Figure 15). The high concentrations at this site are most likely emitted from a natural source; the untreated natural wood material at this site acts as a natural emission source of pinene.

Figure 15. The sampling site with highest concentrations of α- and β-pinene. The untreated natural wood materials act as a source for pinene emission to this indoor environment.

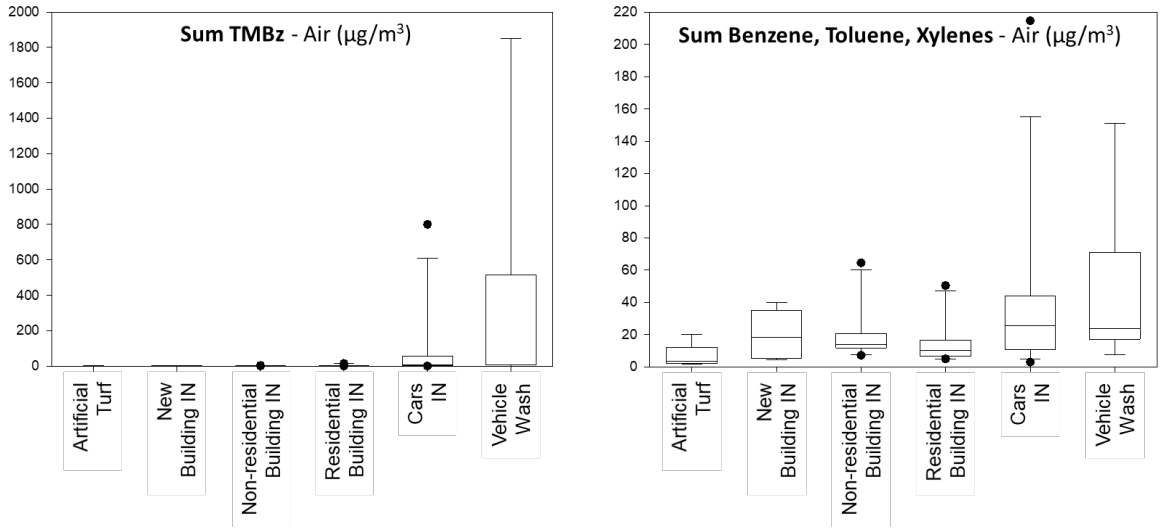


Figure 16: Box-plots of measured concentrations of two groups of VOCs (µg/m^3) (sum TMBz=135-TMBz+124-TMBz+123-TMBz) with high detection in air at vehicle wash facilities and cars. The box-plots represents a range from 25-75% confidence interval with the center line representing the median concentrations and the error bars the outliers, respectively.

Three VOCs; 135-TMBz, 124-TMBz and 123-TMBz, were measured at high concentrations at two washing facilities for cars (especially at one located in a closed garage) and at 100-1000 times higher concentrations inside cars after being cleaned at this washing facility. The same washing facility had elevated concentrations of benzene, toluene and xylenes. Xylenes were also elevated at a furniture shop.

3.3 Semi-volatile organic compounds

The concentration range, average, and detection frequency for the detected semi-volatile organic compounds (SVOCs) are summarized in Table 23 and Table 24. The LoD for compounds not found in any sample type are given in the complete data table in the Appendix.

3.3.1 Water samples

Table 23: Concentration range, average, and detection frequency of SVOCs in WWTP effluent, sludge, surface water, and road tunnel wash water.

	WWTP – Effluent	WWTP – Sludge	Alna river – Surface water	Road tunnel – Wash water	Road tunnel – Sand trap
	ng/L	**ng/g dw**	**ng/L**	**ng/L**	**ng/g dw**
DIPBP	<40 - <40 0 %	<25 - <25 0 %	<40 - <40 0 %	<40 - <40 0 %	<25 – 39 15 11 %
isoTAC	<82 – 1900 535 90 %	<25 - <25 0 %	89 – 1300 413 100 %	78 – 2400 800 100 %	<25 - <25 0 %
TAC	<66 – 1000 202 90 %	<10 - <10 0 %	22 – 1100 308 100 %	<20 – 230 83 89 %	<10 - <10 0 %
CTC	<50 - <50 0 %	79 – 190 130 100 %	<50 - <50 0 %	<50 - <50 0 %	<50 - <50 0 %
TBNPA	<5 - <5 0 %	<10 - <10 0 %	<5 - <5 0 %	<5 – 6 3,2 22 %	<10 - <10 0 %

Average: For the non-detects LoD/2 was used, when calculating the average.

Triallyl isocyanurate (isoTAC) and triallyl cyanurate (TAC), which were used as vulcanization and crosslinking agents (Lanxess), were detected in all water samples from Alna river and in run-off water from the washing of a road tunnel, in concentrations of up to 2 400 ng/L. The brominated flame retardant 3-bromo-2,2-bis(bromomethyl)propanol (TBNPA) were found in a very few samples from road tunnel wash water in concentrations close to the detection limit. The heat transfer fluid bis(1-methylethyl)-1,1'-biphenyl (DIPBP) was found in one sand trap sample from tunnel wash slightly above the limit of detection.

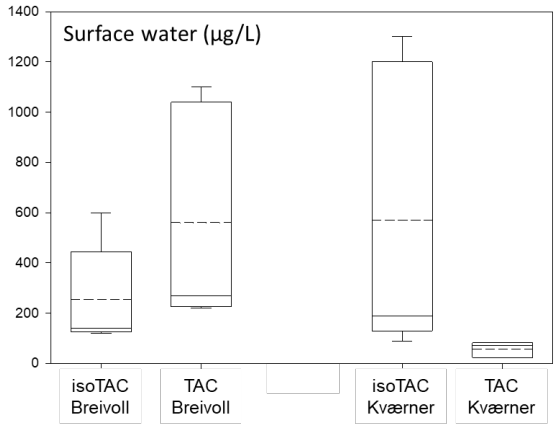


Figure 17: Box-plot of measured concentrations of isoTAC and TAC (µg/L) in surface water from two sampling sites in Alna river; Breivoll and Kværner. The box-plots represents a range from 25-75% confidence interval with the center line representing the median concentrations, the dotted line the average concentrations and the error bars the outliers, respectively.

2-Chlorotrityl chloride (CTC) are easily hydrolyzed to its derivative 2-Chlorophenyl diphenylmethanol (CTA) and are related to the use of the antifungal medicine Clotrimazol. Only the sum of both components (CTC+CTA) could be determined. CTC/CTA are found in all samples of sewage sludge and in comparable high concentrations. These sludge samples are from finally treated sludge and the occurrence of CTC/CTA indicates a high usage of Clotrimazole and the persistency of CTC/CTA (and other Chlorotrityl derivatives as these derivatives may interconvert, but the Chlorotrityl core will persist). CTC/CTA and Clotrimazole were earlier found in agricultural soil (Sabourin, Al-Rajab et al. 2011) and should behave just as like Tris(4-chlorophenyl)methanol (CAS 3010-80-8), which was earlier found in high trophic level birds and mammals (Jarman, Simon et al. 1992).

2-Chlorotrityl chloride (CTC), which was detected in all samples of sewage sludge, is under assessment of ECHA as PBT compound. There are no PNEC established for terrestrial environment, which would be useful for discussion of the environmental risk associated with the use of sewage sludge as fertilizer. It was not detected in surface water samples from Alna river, however, NORMAN NDS (NORMAN 2021) has registered a PNEC for freshwater life of about 100 ng/L, which is a only factor of 2 higher than the limit of detection for this compound in fresh water samples. This resin should be further studied in environmental samples using larger sampling volumes to improve LoDs below the PNEC values for several locations in addition to the Alna river.

TAC is under assessment of ECHA as PBT compound (ECHA 2021). Persistence, bioaccumulation, and toxicity of TAC are of concern. TAC and its isomeric derivative Triallyl isocyanurate (isoTAC) were found with high concentrations in surface water of Alna river and sewage effluent, which are close to the PNEC (3 500 and 6 900 ng/L for freshwater aquatic life) (NORMAN 2021). These findings justify a closer follow-up of these compounds. Whereas many compounds showed insignificant difference between the two freshwater sampling sites Breivoll and Kværner, we could observe significant differences for isoTAC and TAC, with isoTAC: Breivoll < Kværner and TAC: Breivoll>>Kværner. Both compounds are used as crosslinker, but it seems that isoTAC is more used in PE, EVA, EPDM-rubber, and acrylic resins,

whereas TAC are used high-performance unsaturated polyester and acrylate series products and is especially for the high-temperature resistant and high strength glass fiber reinforced plastic (GFRP) products.

3.3.2 Granule, dust and wipes samples

Table 24: Concentration range, average, and detection frequency of SVOCs in artificial turf granules, dust and wipes.

	Artificial turf – Granules	Artificial turf – Dust	Nonres. Building – Dust	Resid. Building – Dust	New building – Dust/Wipes	Cars – Wipes	Vehicle wash – Wipes
	ng/g dw	**ng/sample**	**ng/m²**	**ng/m²**	**ng/m²**	**ng/m²**	**ng/m²**
DET	<1 - <10 0 %	<0,1 - <0,1 0 %	<0,1 – 1,1 0,27 11 %	<0,1 - <0,8 0 %	<0,04 - <0,12 0 %	<0,04 - <0,22 0 %	<0,1 - <0,2 0 %
BT	<1 – 150 16 20 %	<0,1 - <0,1 0 %	<0,1 – 1 0,31 33 %	<0,1 – 0,6 0,18 10 %	<0,04 - <0,12 0 %	<0,04 - <0,22 0 %	<0,1 - <0,1 0 %
isoTAC	<1 – 1,6 1,1 10 %	<0,1 – 0,1 0,06 14 %	<0,2 – 5,9 1,2 78 %	<0,1 – 6,9 1,2 70 %	<0,04 – 1,3 0,41 71 %	0,04 – 1,4 0,68 100 %	<0,1 – 0,9 0,30 60 %
TAC	<5 - <50 0 %	<0,5 - <0,5 0 %	<0,4 - <4 0 %	<0,2 - <4 0 %	<0,16 – 1,1 0,31 14 %	<0,16 – 4,5 0,99 18 %	<0,2 - <0,5 0 %
TBNPA	<1 – 26 3,1 10 %	<0,1 - <0,1 0 %	<0,1 – 30 3,9 11 %	<0,1 - <0,8 0 %	<0,04 - <0,12 0 %	<0,04 - <0,22 0 %	<0,1 - <0,1 0 %

Average: For the non-detects LoD/2 was used, when calculating the average.

The brominated flame retardant 3-bromo-2,2-bis(bromomethyl)propanol (TBNPA) was found in granules from an indoor melted rubber flooring with a concentration of 26 ng/g. It was also detected in the dust sample from the same site (playland) at 30 ng/m^2, suggesting the rubber carpet acting as a potential source both through emission and mechanical tearing of particles during use. It was not detected in any other granule or dust sample.

Of the SVOCs, only isoTAC was detected in all sample types related to indoor environments, artificial turf, and cars. The highest concentrations of isoTAC were measured at two residential buildings, one playland and one clothes/equipment shop. TAC was only detected in two new electrical cars and a newly build museum. The detected concentrations of TAC at these three sites were higher than the concentrations of isoTAC at the same sites.

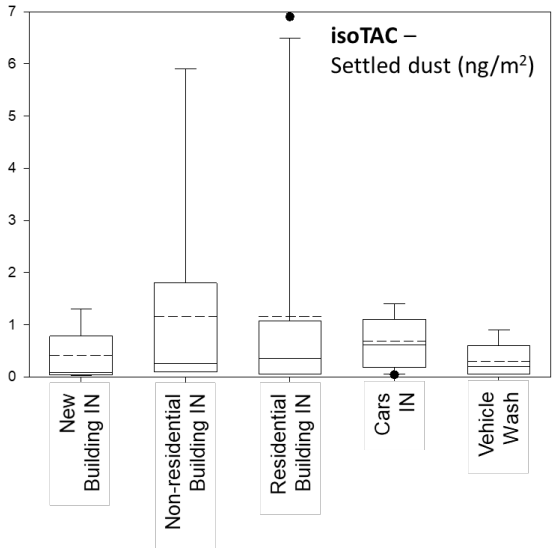


Figure 18: Box-plot of measured concentrations of isoTAC (ng/m^2) in dust/wipes from buildings, cars and vehicle washing facilities. The box-plots represents a range from 25-75% confidence interval with the center line representing the median concentrations, the dotted line the average concentrations and the error bars the outliers, respectively.

3.4 Dechloranes

The concentration range, average, and detection frequency for the detect dechloranes are summarized in Table 25 and Table 26. The LoD for samples not found in any sample type are given in the complete data table in the Appendix.

3.4.1 Sludge, sediment and biota samples

Table 25: Concentration range, average, and detection frequency of the dechlorane compounds in WWTP sludge, soil/sediment, fish liver (Cod and Whitening), and herring gull eggs.

	WWTP – Sludge	Marinas – Soil/Sed	Oslo fjord – Fish liver	Oslo fjord – Herring gull egg	Road tunnel – Sand trap
	ng/g dw	**ng/g dw**	**ng/g ww**	**ng/g ww**	**ng/g ww**
Dec602	<0,1 - <0,1 0 %	<0,1 – 0,18 0,06 10 %	0,15 – 0,62 0,34 100 %	0,03 – 0,08 0,05 100 %	<0,1 - <0,2 0 %
Dec603	<0,1 - <0,1 0 %	<0,1 - <0,1 0 %	<0,1 - <0,1 0 %	<0,02 – 0,04 0,02 33 %	<0,1 - <0,2 0 %
Dec604	<3,3 - <3,4 0 %	<1,6 - <3,4 0 %	<5,1 - <5,1 0 %	<1 - <1 0 %	<3,1 - <10 0 %

Dec601	<0,3 - <0,3 0 %	<0,2 - <0,3 0 %	<0,4 - <0,4 0 %	<0,1 - <0,1 0 %	<0,2 - <0,8 0 %
DPsyn	1,4 – 9,5 2,4 100 %	<0,5 – 1,7 0,63 50 %	<0,9 - <0,9 0 %	<0,2 – 1 0,31 67 %	<1,26 – 1,9 1,0 67 %
DPanti	3,1 – 33 6,8 100 %	0,45 – 3,6 1,7 100 %	0,82 – 1,2 0,95 100 %	0,27 – 3,3 0,93 100 %	0,54 – 4,3 1,8 100 %

Average: For the non-detects LoD/2 was used, when calculating the average.

Four of the dechlorane compounds, Chlordene Plus (CdeneP), 1,3-Dechlorane plus (13-DPMA), 1,5-Dechlorane plus (15-DPMA) and Dechlorane 604 (Dec604), were not detected in any of the samples. Two other dechlorane compounds, Dechlorane 602 (Dec602) and 603 (Dec603), were detected in biota samples. Dec602 was found in all biota samples (fish liver and herring gull eggs) and several of the marina sediment/soil samples with the highest concentrations found in fish liver. Dec603 was detected only in two of the herring gull eggs at concentrations close to the LoD. DPanti was detected in sludge, sediment and soil from marinas, fish liver, bird eggs from Oslofjord, and in samples of the sand trap used during road tunnel wash, whereas DP syn was detected less frequently and not at all in fish liver.

3.4.2 Dust and wipes samples

Table 26: Concentration range, average, and detection frequency of detected dechlorane compounds in dust and wipes samples.

	Vehicle wash – Wipes	Artificial turf – Dust	Nonres. Building – Dust	Resid. Building – Dust	New building – Dust/Wipes	Cars – Wipes
	ng/m²	**ng/sample**	**ng/m²**	**ng/m²**	**ng/m²**	**ng/m²**
DPsyn	<0,42 – 1,2 0,64 67 %	<0,5 - <1,7 0 %	<0,7 – 63 11 56 %	<0,24 – 3,2 1,1 20 %	<0,16 – 0,43 0,22 14 %	<0,68 – 1,2 0,55 27 %
DPanti	<0,18 – 2,8 1,1 83 %	<0,2 – 0,5 0,22 29 %	1,7 – 45 13 100 %	0,29 – 8,1 2,0 100 %	<0,12 – 1 0,36 57 %	<0,28 – 3,5 0,59 36 %

Average: For the non-detects LoD/2 was used, when calculating the average.

The dechlorane plus compounds, syn (DPsyn) and anti (DPanti), were detected in most of the sampling groups. The concentrations were higher in dust/wipes samples from existing residential and non-residential buildings than from newly constructed/renovated buildings. DPanti was detected to higher extent and in most samples at higher concentrations than DPsyn.

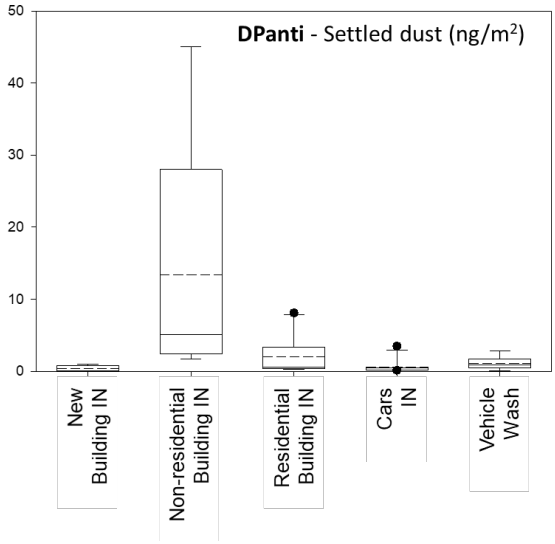


Figure 19: Box-plot of measured concentrations of DPanti (ng/m^2) in dust/wipes from buildings, cars and vehicle washing facilities. The box-plots represents a range from 25-75% confidence interval with the centre line representing the median concentrations, the dotted line the average concentrations and the error bars the outliers, respectively.

3.5 Plasticizers

The concentration range, average, and detection frequency for the detected plasticizers are summarized in Table 27 and Table 28. The LoD for samples not found in any sample type are given in the complete data table in the Appendix.

3.5.1 Water, soil, and sediment samples

Table 27: Concentration range, average, and detection frequency of plasticizer compounds in WWTP effluent, surface, and tunnel-wash water, soil/sediment.

	WWTP Effluent	Alna river Surface water	Marinas Soil/Sed	Road tunnel Wash water
	ng/L	**ng/L**	**ng/g dw**	**ng/L**
ATBC	<9 - <505 0 %	<24 - <80 0 %	<3 – 8,2 2,4 20 %	<1 - <80 0 %
TOTM	<20 - <20 0 %	<20 - <20 0 %	<5 – 8,8 3,7 20 %	<20 - <20 0 %
DEP	<90 – 250 75 20 %	<90 - <90 0 %	<1 – 1,4 0,66 20 %	<90 – 180 60 11 %
DiBP	<40 – 250 83 50 %	<40 - <40 0 %	<1 – 1,8 0,63 10 %	<40 – 120 37 22 %
DnBP	<140 – 2000 679 90 %	<140 – 250 88 10 %	<1 – 23 2,9 30 %	<140 – 250 90 11 %
BMEP	<20 – 330 49 20 %	<20 - <20 0 %	<1 - <1 0 %	<20 – 8900 1 020 33 %
BBP	<20 – 47 14 10 %	<20 - <20 0 %	<1 – 3,2 0,77 10 %	<20 - <20 0 %
DEHP	<150 – 980 312 70 %	<150 – 300 122 30 %	<1 – 95 22 40 %	<150 – 380 232 67 %
DCHP	<20 - <20 0 %	<20 - <20 0 %	<1 – 37 8,1 70 %	<20 - <20 0 %
DiNP	<25000 – 530 000 175 000 70 %	<25000 – 83 000 19 600 10 %	<0 - <83 0 %	<25 000 – 140 000 56 200 67 %
DiDP	<3600 – 360 000 56 200 90 %	<700 – 23 000 10 800 90 %	<0 - <388 0 %	9500 – 100 000 31 800 100 %
TEP	<110 – 700 136 30 %	<110 – 5400 1 110 90 %	<3 - <3 0 %	<110 – 480 102 11 %
TNBP	<50 – 2500 572 90 %	<50 – 330 126 70 %	<3 - <3 0 %	<50 – 560 86 11 %

	WWTP Effluent	Alna river Surface water	Marinas Soil/Sed	Road tunnel Wash water
	ng/L	**ng/L**	**ng/g dw**	**ng/L**
TCEP	<70 - <70 0 %	<70 – 430 75 10 %	<3 - <3 0 %	<70 – 400 76 11 %
TCIPP	<130 – 76 000 14 700 90 %	310 – 3800 1 870 100 %	<3 - <3 0 %	<130 – 1100 263 22 %
TBOEP	<20 – 5400 1 400 50 %	<20 – 860 95 10 %	<3 - <3 0 %	<20 - <20 0 %
TDCIPP	<20 – 6200 1 130 50 %	<20 – 150 45 40 %	<10 - <10 0 %	<20 - <20 0 %
TPHP	<130 – 1200 349 50 %	<130 – 300 89 10 %	<3 - <3 0 %	<130 - <130 0 %
EHDP	<20 - <20 0 %	<20 - <20 0 %	<3 – 45 14 60 %	<20 - <20 0 %
TEHP	<20 - <20 0 %	<20 - <20 0 %	<3 - <3 0 %	<20 – 91 40 56 %
2IPPDPP	<20 - <20 0 %	<20 - <20 0 %	<20 – 76 17 10 %	<20 - <20 0 %
TMTP	<20 - <20 0 %	<20 - <20 0 %	<2 – 29 13 60 %	<20 - <20 0 %
4IPPDPP	<20 - <20 0 %	<20 - <20 0 %	<20 – 11 10 10 %	<20 - <20 0 %
pro T2IPPP	<20 - <20 0 %	<20 - <20 0 %	<3 – 5,1 1,9 10 %	<20 - <20 0 %
IDDPP	<12 – 190 26 10 %	<12 - <12 0 %	<2 – 5,1 1,6 20 %	<12 - <12 0 %

Average: For the non-detects LoD/2 was used, when calculating the average.

Many plasticizers were only occasionally detected in effluent and surface water, soil and sediment from marinas, and road tunnel wash. However, some of the “classical” phthalates like DnBP, DEHP, DiNP, DiDP, TCIPP were detected frequently and in high concentrations in these samples. The large-scale use of these common plasticizers in the home environment, packaging and in cars and leisure boats is reflected in the environmental levels for the sample types given in Table 27.

3.5.2 Granule, dust, and wipes samples

Table 28: Concentration range, average, and detection frequency of plasticizer compounds in artificial turf granules, dust and wipes samples.

	Vehicle wash – Wipes	Artificial turf – Granules	Artificial turf – Dust	Nonres. Building – Dust	Resid. Building – Dust	New building – Dust/wipes	Cars – Wipes
	ng/m²	**ng/g**	**ng/sample**	**ng/m²**	**ng/m²**	**ng/m²**	**ng/m²**
ATBC	<6 – 320 97 50 %	<5 – 26 14 40 %	<21 - <21 0 %	<38 – 130000 17 100 89 %	20 – 160000 16 800 100 %	10 – 26000 4 020 100 %	<14 – 240 61 36 %
NPGD	<69 - <150 0 %	<150 - <150 0 %	<230 - <230 0 %	<120 - <1200 0 %	<68 – 480 246 10 %	<46 - <180 0 %	<48 - <330 0 %
DDcP	<8 – 4600 783 50 %	<5 - <5 0 %	<15 - <15 0 %	<7,8 – 31000 3 520 56 %	<4,5 – 220 58 30 %	<3,1 - <12 0 %	<9,6 – 72000 6 600 55 %
TOTM	47 – 38000 6 680 100 %	<5 - <5 0 %	<15 – 160 29 14 %	120 – 7500 1 760 100 %	87 – 26000 4 520 100 %	10 – 570 229 100 %	60 – 31000 3 380 100 %
DiBP	<230 - <490 0 %	<2 – 73 13 40 %	<750 - <750 0 %	<390 – 3500 1 060 11 %	<230 – 1100 780 20 %	<150 - <600 0 %	<160 - <1100 0 %
DnBP	<140 – 350 148 17 %	<2 – 1600 166 30 %	<450 - <450 0 %	<230 – 82000 11 300 44 %	<140 – 4400 1 270 30 %	<92 – 450 150 29 %	<97 - <650 0 %
BMEP	<3 - <6 0 %	<2 - <2 0 %	<9 - <9 0 %	<4,7 - <48 0 %	<2,7 - <48 0 %	<1,8 – 29 5,8 14 %	<1,9 - <13 0 %
DMPP	<3 - <6 0 %	<2 - <2 0 %	<9 - <9 0 %	<4,7 – 22000 2 450 11 %	<2,7 – 110 18 10 %	<1,8 – 5400 944 29 %	<1,9 - <13 0 %
BEEP	<6 - <14 0 %	<2 - <2 0 %	<21 - <21 0 %	<11 – 1800 219 11 %	<6,3 - <110 0 %	<4,3 - <17 0 %	<4,5 - <30 0 %
BBP	<3 - <6 0 %	<2 - <2 0 %	<9 - <9 0 %	<14 – 6100 839 89 %	<16 – 750 184 70 %	<1,8 – 63 14 29 %	<1,9 – 55 9,2 9 %
DBOEP	<5 - <10 0 %	<2 - <2 0 %	<15 - <15 0 %	<7,8 – 5100 580 11 %	<4,5 - <80 0 %	<3,1 - <12 0 %	<3,2 - <22 0 %
DEHP	43 – 670000 113 000 100 %	<2 – 8200 1 110 80 %	<9 – 96 32 29 %	1800 – 300000 53 500 100 %	1000 – 86000 14 700 100 %	26 – 930 261 100 %	<17 – 1600 411 91 %
DCHP	<3 - <6 0 %	<2 - <2 0 %	<9 - <9 0 %	<4,7 – 2100 458 33 %	<5,2 – 1600 357 40 %	<1,8 – 2100 583 86 %	<1,9 – 440 51 18 %
DiNP	9600 – 4400000 844 000 100 %	<270 – 26000 10 600 70 %	<6000 – 20000 5 430 14 %	77000 – 19000000 3 080 000 100 %	25000 – 1900000 339 000 100 %	8900 – 89000 28 500 100 %	<7300 – 320000 102 000 82 %

	Vehicle wash – Wipes	Artificial turf – Granules	Artificial turf – Dust	Nonres. Building – Dust	Resid. Building – Dust	New building – Dust/wipes	Cars – Wipes
	ng/m²	**ng/g**	**ng/sample**	**ng/m²**	**ng/m²**	**ng/m²**	**ng/m²**
DNP	<22 – 3300 676 50 %	<20 - <20 0 %	<60 - <60 0 %	<31 - <320 0 %	<18 – 1100 202 20 %	<12 - <48 0 %	<13 – 120 52 27 %
DiDP	<800 – 110000 65 900 83 %	<38 - <977 0 %	<1500 - <1500 0 %	30000 – 2400000 404 000 100 %	9900 – 540000 167 000 100 %	2700 – 11000 6 470 100 %	<1700 – 290000 52 800 91 %
TEP	<46 – 340 86 17 %	<15 – 450 59 20 %	<9 - <9 0 %	<78 - <800 0 %	<45 - <800 0 %	<3,7 – 19 9,5 43 %	<32 - <220 0 %
TNBP	<3 - <6 0 %	<15 – 190 26 10 %	<9 - <9 0 %	<930 – 7400 2 570 11 %	<540 - <9600 0 %	<1,8 – 230 50 57 %	<130 - <870 0 %
TCEP	<14 – 880 288 67 %	<15 – 2200 227 10 %	<9 - <9 0 %	<470 – 24000 5 440 33 %	<270 – 5500 1 810 40 %	<55 – 290 100 29 %	<160 – 330000 36 400 27 %
TCIPP	<23 – 2100 702 67 %	<15 – 140000 14 000 30 %	<9 - <9 0 %	<470 – 900000 102 000 22 %	<270 – 230000 25 300 40 %	46 – 17000 2 680 100 %	<130 – 1700 716 36 %
TBOEP	<3 – 2800 509 50 %	<140 - <140 0 %	<45 - <45 0 %	1300 – 1300000 151 000 100 %	<69 – 14000 3 570 80 %	<2,4 – 820 233 57 %	<120 – 7200 1 910 91 %
TDCIPP	<5 – 39000 6 550 50 %	<15 - <15 0 %	<9 - <9 0 %	63 – 150000 17 400 100 %	<2,7 – 770 177 80 %	<1,8 – 160 41 71 %	<8,7 – 40000 8 590 91 %
TPHP	<3 – 85 18 33 %	<15 – 1900 197 10 %	<9 - <9 0 %	23 – 79000 11 500 100 %	<12 – 760 148 80 %	7,6 – 280 67 100 %	<11 – 9600 1 860 91 %
EHDP	<3 – 690 139 67 %	<15 – 6000 614 20 %	<9 - <9 0 %	140 – 280000 33 700 100 %	<5,6 – 1500 222 80 %	<6,5 – 520 96 86 %	<10 – 4800 977 73 %
TEHP	<5 – 2400 624 83 %	<15 – 390000 75 700 70 %	<9 - <9 0 %	<16 – 810000 90 300 78 %	<2,7 – 1200 228 80 %	<1,8 – 17 4,8 29 %	<8,7 – 7200 864 64 %
2IPPDPP	<3 - <6 0 %	<15 – 2400 247 10 %	<9 - <9 0 %	<4,7 – 12000 1 340 11 %	<2,7 - <48 0 %	<1,8 – 14 3,7 14 %	<1,9 - <13 0 %
TPTP	<3 - <6 0 %	<15 - <15 0 %	<9 - <9 0 %	<4,7 - <48 0 %	<2,7 - <48 0 %	<1,8 - <7,1 0 %	<1,9 – 55 9,0 9 %
V6	<3 – 62 24 50 %	<5 - <5 0 %	<9 - <9 0 %	<13 – 3200 649 89 %	<5,2 – 74 23 50 %	<1,8 – 41 7,6 14 %	<5,6 – 2,8 4,6 9 %
IDDPP	<5 – 1200 239 67 %	<15 – 300 37 10 %	<9 - <9 0 %	360 – 400000 47 700 100 %	28 – 53000 5 560 100 %	<3,4 – 59 21 71 %	<11 – 560 218 91 %

Average: For the non-detects LoD/2 was used, when calculating the average.

Acetyl tributyl citrate (ATBC), didecyl phthalate (DDcP), tris(2-ethylhexyl) trimellitate (TOTM), benzyl butyl phthalate (BBP), phosphoric acid, 2,2-bis(chloromethyl)-1,3-propanediyl tetrakis(2-chloroethyl) ester (V6), and isodecyl diphenyl phosphate (IDDPP) were frequently detected in samples from the indoor-related environments. In artificial turf granules, the same compounds were not detected or detected at low concentrations. ATBC, TOTM and IDDPP were found at elevated concentrations in residential and non-residential existing buildings (up to 100s of µg/m^2). Also, many of phthalates like di-iso-nonyl phthalate (DiNP), di-iso-decyl phthalate (DiDP), tris(2-chloroisopropyl) phosphate (TCIPP), tris(2-butoxyethyl) phosphate (TBOEP), and neopentyl glycol dibenzoate (NPGD), were detected at very high concentrations (up to mg/m^2 of dust) in settled dust from residential, non-residential environments but also in vehicle washing facilities and cars. These values are most probably underestimated as these concentrations are way above the calibrated quantification range. Lower concentrations were generally found for most of the plasticizers in the newly constructed/renovated buildings, but high concentrations were observed at these sites for DiNP and DiDP.

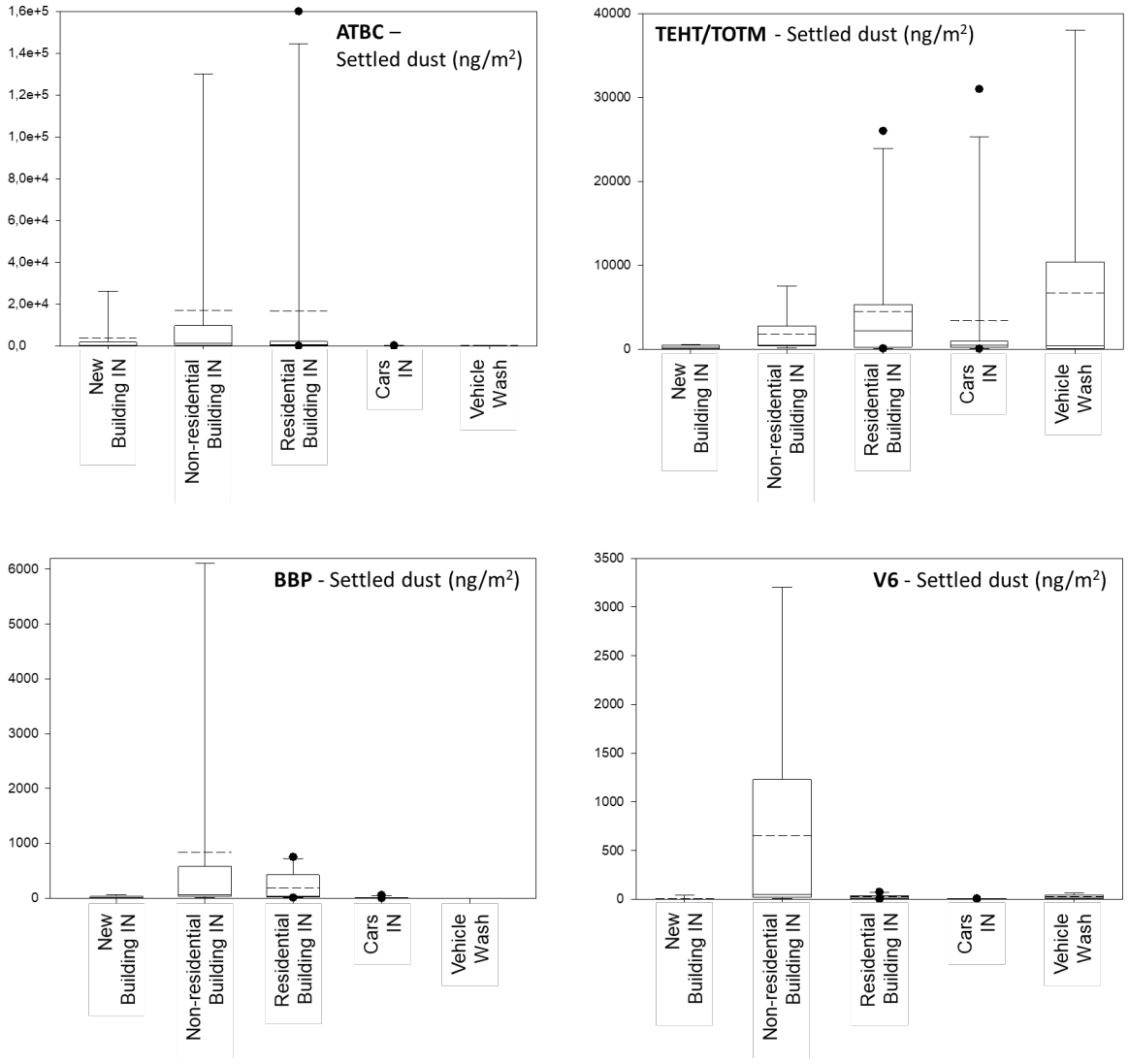


Figure 20: Box-plot of measured concentrations of four plasticizers (ng/m^2) with high detection in settled dust at indoor sites from buildings, cars and vehicle washing facilities. The box-plots represents a range from 25-75% confidence interval with the center line representing the median concentrations, the dotted line the average concentrations and the error bars the outliers, respectively.

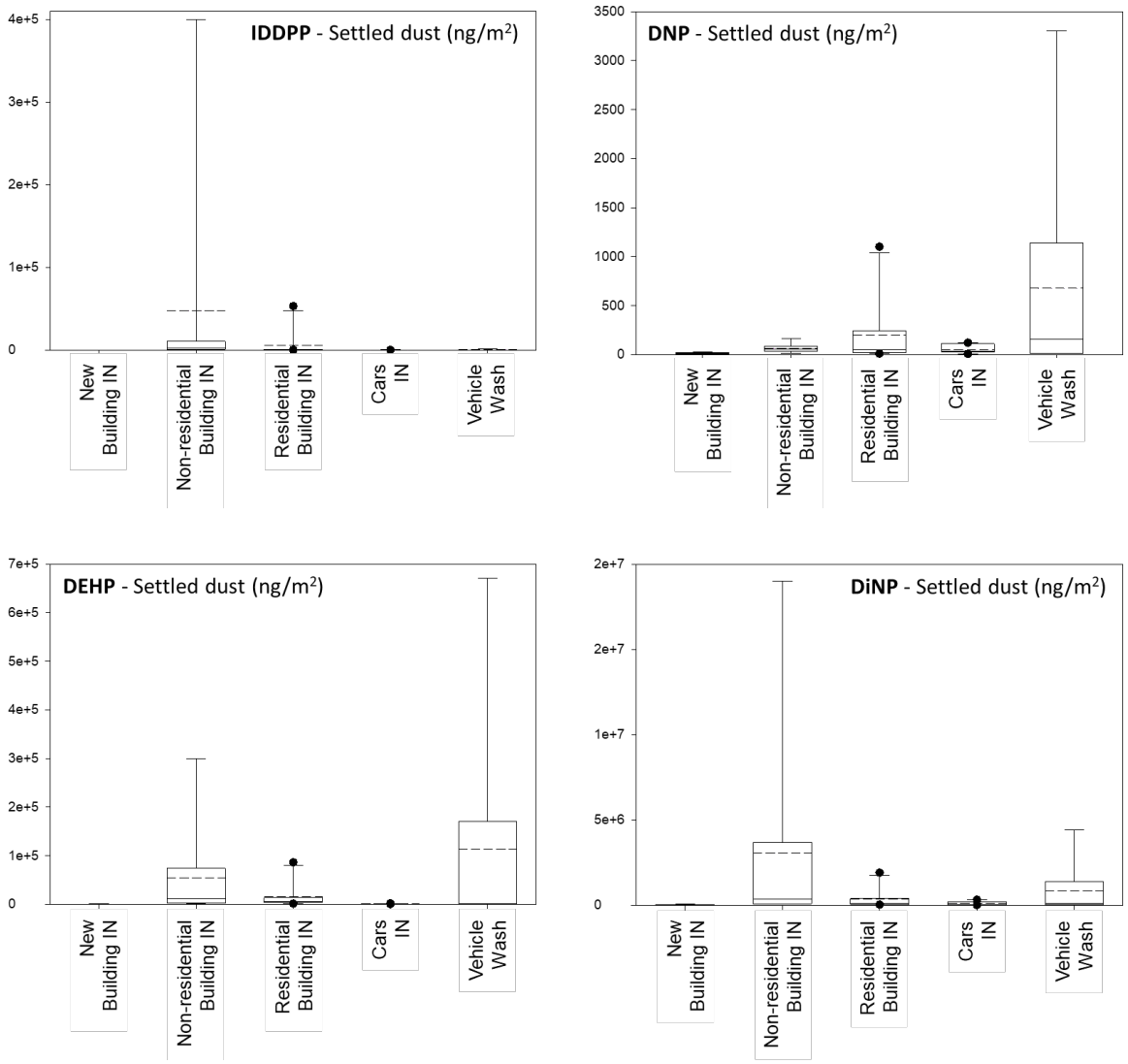


Figure 21: Box-plot of measured concentrations of four plasticizers (ng/m^2) with high detection in settled dust at indoor sites from buildings, cars and vehicle washing facilities. The box-plots represents a range from 25-75% confidence interval with the center line representing the median concentrations, the dotted line the average concentrations and the error bars the outliers, respectively.

Acetyl tributyl citrate (ATBC) is a phthalate substitute used in food and medical plastics, cosmetics, and toys. It is evaluated to be systemically safe when exposed by up to 1000 mg/kg/day. However, newer studies have seen reproductive toxicity in female mice at levels below 10 mg/kg/day and request further information to better understand the impact of ATBC on female reproduction in mice (Rasmussen, Sen et al. 2017).

Phthalates are widely used compounds and people are exposed to them on a large scale. Since phthalates are only loosely bound to the plastic matrix, they can leach out and contaminate the peripheral environment, which is shown in this study for a lot of different cases. Various animal and human studies have revealed vital health problems, including developmental and reproductive toxicity from phthalate exposure (Sedha, Lee et al. 2021). The transitional or medium molecular weight phthalates like DEHP, BBp, DiBP, or DnBP are associated with reproductive effects such as decreased fertility, reduced testicular weight, accessory reproductive organ variations, and several female reproductive disorders appeared largely to be related to. Among the higher molecular weight phthalates (≥ C7), diisononyl phthalate (DiNP) has some minor effects on the development of male reproductive organs. In 2003 a European risk assessment on DiNP (ECB 2003) concluded with no adverse chemical effects towards the aquatic ecosystem. However, the NORMAN Ecotoxicology database (NORMAN 2021) has registered a quite low PNEC for freshwater life of ~ 7 ng/L, the concentrations measured in Alna river are far above that.

3.6 Secondary diphenyl amine compounds and analytically related compounds

The concentration range, average, and detection frequency for the detected secondary diphenyl amine compounds (SDPAs) and analytically related compounds are summarized in Table 29 and Table 30. The LoD for samples not found in any sample type are given in the complete data table in the Appendix.

3.6.1 Water, sludge, sediment, and soil samples

Table 29: Concentration range, average, and detection frequency of SDPAs in water, sludge, sediment/soil, fish liver, and eggs.

	WWTP – Effluent	WWTP – Sludge	Alna river – Surface water	Marinas – Soil/Sed	Oslo fjord – Fish liver	Oslo fjord – Herring gull egg	Road tunnel – Wash water	Road tunnel – Sand trap
	ng/L	**ng/g dw**	**ng/L**	**ng/g dw**	**ng/g ww**	**ng/g ww**	**ng/L**	**ng/g dw**
PhDPA	<10 - <10 0 %	<0,5 - <0,5 0 %	<10 - <10 0 %	<0,5 - <0,5 0 %	<0,5 - <0,5 0 %	<0,5 - <0,5 0 %	<10 – 46 9,6 11 %	<0,5 - <0,5 0 %
TeMeDPA	<10 - <10 0 %	<0,5 - <0,5 0 %	<10 - <10 0 %	<0,5 - <0,5 0 %	<0,5 - <0,5 0 %	<0,5 - <0,5 0 %	<10 – 36 8,4 11 %	<0,5 - <0,5 0 %
tBuDPA	<10 - <10 0 %	16 – 49 34 100 %	<10 - <10 0 %	<0,5 – 12 1,4 10 %	<0,5 - <0,5 0 %	<0,5 - <0,5 0 %	35 – 650 150 100 %	6,2 – 75 28 100 %
DiMeFluDPA	<10 - <10 0 %	<0,5 - <0,5 0 %	<10 - <10 0 %	<0,5 - <0,5 0 %	<0,5 - <0,5 0 %	<0,5 - <0,5 0 %	<10 – 20 6,7 11 %	<0,5 - <0,5 0 %
DtBuDPA	<10 - <10 0 %	25 – 56 41 100 %	<10 - <10 0 %	<0,5 – 11 1,6 20 %	<0,5 - <0,5 0 %	<0,5 - <0,5 0 %	100 – 1600 392 100 %	5,1 – 42 18 100 %
diAMS	<10 - <10 0 %	46 – 120 82 100 %	<10 - <10 0 %	<0,5 – 47 4,9 10 %	<0,5 - <0,5 0 %	<0,5 - <0,5 0 %	60 – 250 140 100 %	6,5 – 35 20 100 %
DiHxDPA	<10 - <10 0 %	<0,5 - <0,5 0 %	<10 - <10 0 %	<0,5 - <0,5 0 %	<0,5 - <0,5 0 %	<0,5 - <0,5 0 %	<10 - <10 0 %	<0,5 - <0,5 0 %
DitOcDPA	<10 - <10 0 %	120 – 170 141 100 %	<10 - <10 0 %	14 – 61 29 100 %	<0,5 - <0,5 0 %	<0,5 - <0,5 0 %	940 – 7200 2 370 100 %	74 – 1200 406 100 %
MDA	<10 - <10 0 %	2,4 – 6,5 4,4 100 %	<10 - <10 0 %	<1 - <1 0 %	<1 - <1 0 %	<1 - <1 0 %	<10 - <10 0 %	<1 - <1 0 %
DBM	<10 - <10 0 %	<1 - <1 0 %	<10 - <10 0 %	<1 - <1 0 %	<1 - <1 0 %	<1 - <1 0 %	<10 - <10 0 %	5,5 – 18 9,8 100 %
Iodocarb	<10 - <10 0 %	<1 - <1 0 %	<10 - <10 0 %	<1 - <1 0 %	<1 - <1 0 %	<1 - <1 0 %	<10 – 630 74 11 %	<1 - <1 0 %

	WWTP – Effluent	WWTP – Sludge	Alna river – Surface water	Marinas – Soil/Sed	Oslo fjord – Fish liver	Oslo fjord – Herring gull egg	Road tunnel – Wash water	Road tunnel – Sand trap
	ng/L	**ng/g dw**	**ng/L**	**ng/g dw**	**ng/g ww**	**ng/g ww**	**ng/L**	**ng/g dw**
VSU	<10 - <10 0 %	<1 - <1 0 %	<10 - <10 0 %	<1 - <1 0 %	<1 - <1 0 %	<1 - <1 0 %	<10 – 220 67 33 %	<1 - <1 0 %
MFPDE	<10 - <10 0 %	<1 - <1 0 %	<10 - <10 0 %	<1 - <1 0 %	<1 - <1 0 %	<1 - <1 0 %	<10 – 54 11 11 %	<1 - <1 0 %
Tinopal	410 – 1100 701 100 %	860 – 1800 1153 100 %	<10 - <10 0 %	<1 - <1 0 %	<1 - <1 0 %	<1 - <1 0 %	<10 - <10 0 %	<1 - <1 0 %
Iscotrizinol	<10 - <10 0 %	110 – 220 179 100 %	<10 - <10 0 %	<1 - <1 0 %	<1 - <1 0 %	<1 - <1 0 %	<10 - <10 0 %	<1 - <1 0 %
6PPD-Q	<10 – 160 47 50 %	<1 - <1 0 %	<10 – 230 28 10 %	<1 – 1500 211 40 %	<1 - <1 0 %	<1 - <1 0 %	2500 – 18000 6 080 100 %	150 - 800 400 100 %

Average: For the non-detects LoD/2 was used, when calculating the average.

Four of the 14 measured SDPAs; 4-tert-Butylphenylphenylamine (tBuDPA), Bis(4-tert-butylphenyl)-amine (DtBuDPA), 4-(2-Phenylpropan-2-yl)-N-[4-(2-phenylpropan-2-yl)phenyl]-aniline (diAMS), and N,N-Bis(4-tert-octylphenyl)amine (DitOcDPA), were found in all samples of sewage sludge, road tunnel wash (run-off water and sandtrap sediment). They were also present in 50 to 60 % of all artificial turf granules and to some degree in sediments from marinas and dust from non-residential buildings.

Due to their low water solubility and lipophilic character (LogKow > 5), SDPAs tend to partition into soil, sediments, or sludge, that means material rich in organic matter. The high concentrations of tBuDPA, DtBuDPA ,diAMS, and DitOcDPA in finally treated sludge indicate a very limited degradation of these compounds, which also were observed in a recent study (Zhang, Zhang et al. 2021, Zhang, Zhang et al. 2021). There is no PNEC established for the terrestrial environment, however, according to ECHA (ECHA 2021) diAMS and DitOcDPA are not readily biodegradable and may cause long lasting harmful effects to aquatic life. The potential environmental risk of these compounds both on the terrestrial and freshwater environment should be examined in more detail in dedicated studies.

The whitener and UV-stabilizer Tinopal and the sunscreen Iscotrizinol were found in all sewage sludge samples in high concentrations. Tinopal was also present in all effluent samples from Bekkelaget WWTP. Both compounds are under assessment of ECHA as PBT compounds (ECHA 2021). They were not detected in surface water samples from Alna river. However, NORMAN NDS (NORMAN 2021) has for Iscotrizionol registered a PNEC for freshwater life of about 19 ng/L, which is only a factor of 2 higher than the limit of detection for this compound. These compounds should be studied with improved LoD in more detail.

The levels of 6PPD-Q in tunnel wash water were in the range of 2 500 – 18 000 ng/L, which are, with exception of DiNP and DiDP, the highest found in this matrix. The chronic toxicity of the parent compound 6PPD to fish in a Early-Life Stage Toxicity Test according to OECD Guideline 210 is 3700 ng/L. (30d NOEC, National Institute of Technology and Evaluation, Japan, 2003).

3.6.2 Granule, dust, and wipes samples

Table 30: Concentration range, average, and detection frequency of SDPAs in artificial turf granules, dust and wipes.

	Vehicle wash Wipes	Artificial turf Granules	Artificial turf Dust	Nonres. Building Dust	Resid. Building Dust	New building Dust/Wipes	Cars Wipes
	ng/m²	**ng/g**	**ng/sample**	**ng/m²**	**ng/m²**	**ng/m²**	**ng/m²**
tBuDPA	<2,8 – 10 3,5 17 %	<0,5 – 470 76 60 %	<12 - <12 0 %	<4 – 92 20 11 %	<14 – 42 20 10 %	<2 - <7 0 %	<1 – 270 33 18 %
DtBuDPA	<2,8 – 34 7,5 17 %	<0,5 – 620 194 60 %	<12 - <12 0 %	<4 – 120 25 11 %	<14 - <38 0 %	<2 - <7 0 %	<1 – 370 42 18 %
diAMS	<3,5 – 5,1 2,7 17 %	<0,5 – 1900 361 50 %	<12 - <12 0 %	<7 – 110 33 44 %	<14 – 120 38 10 %	<2 - <7 0 %	<1 - <13 0 %
DitOcDPA	<3,5 – 58 21 50 %	<0,5 – 1600 459 60 %	<12 - <12 0 %	<20 – 400 90 67 %	<14 – 89 48 20 %	<2 - <7 0 %	<1 – 260 31 18 %
MDA	<5,7 - <12 0 %	<1 – 16 3,5 40 %	<23 - <23 0 %	<8 - <83 0 %	<27 - <77 0 %	<4 - <14 0 %	<3 – 310 54 18 %
DBM	<5,7 - <12 0 %	<1 - <1 0 %	<23 - <23 0 %	<22 – 1700 514 56 %	<27 - <77 0 %	<4 - <14 0 %	<3 – 350 59 18 %
Iodocarb	<5,7 - <12 0 %	<1 - <1 0 %	<23 - <23 0 %	<8 - <83 0 %	<27 - <77 0 %	<5 – 1100 301 57 %	<3 - <25 0 %
VSU	<5,7 - <12 0 %	<1 - <1 0 %	<23 - <23 0 %	<8 – 260 57 11 %	<27 - <77 0 %	<4 – 740 109 14 %	<3 - <25 0 %
Solvent Y 124	<5,7 - <12 0 %	<1 - <1 0 %	<23 - <23 0 %	<8 - <83 0 %	<27 - <77 0 %	<4 – 62 12 14 %	<3 - <25 0 %
Tinopal	<5,7 - <12 0 %	<1 - <1 0 %	<23 - <23 0 %	<8 – 3000 773 22 %	<45 – 750 209 10 %	<4 – 140 23 14 %	<3 - <25 0 %
Iscotrizinol	<5,7 – 65 14 17 %	<1 - <1 0 %	<23 - <23 0 %	<860 – 13000 3 450 67 %	<3000 – 15000 7 400 40 %	<4 – 170 63 57 %	<17 – 17000 1 990 73 %
6PPD-Q	<6,9 – 1200 231 50 %	2,1 – 2500 1 160 100 %	<23 – 110 45 57 %	<8 - <83 0 %	<27 - <77 0 %	<4 - <14 0 %	<17 – 980 106 18 %

Average: For the non-detects LoD/2 was used, when calculating the average.

Four SDPAs were frequently detected in artificial turf granules; tBuDPA, DtBuDPA, diAMS, and DitOcDPA. All of them were detected in the rubber granules but not in the alternative fillings or melted rubber flooring. The same SDPAs were also detected in the dust from the playland (non-residential) and three of them (not diAMS) were detected in two of the new cars.

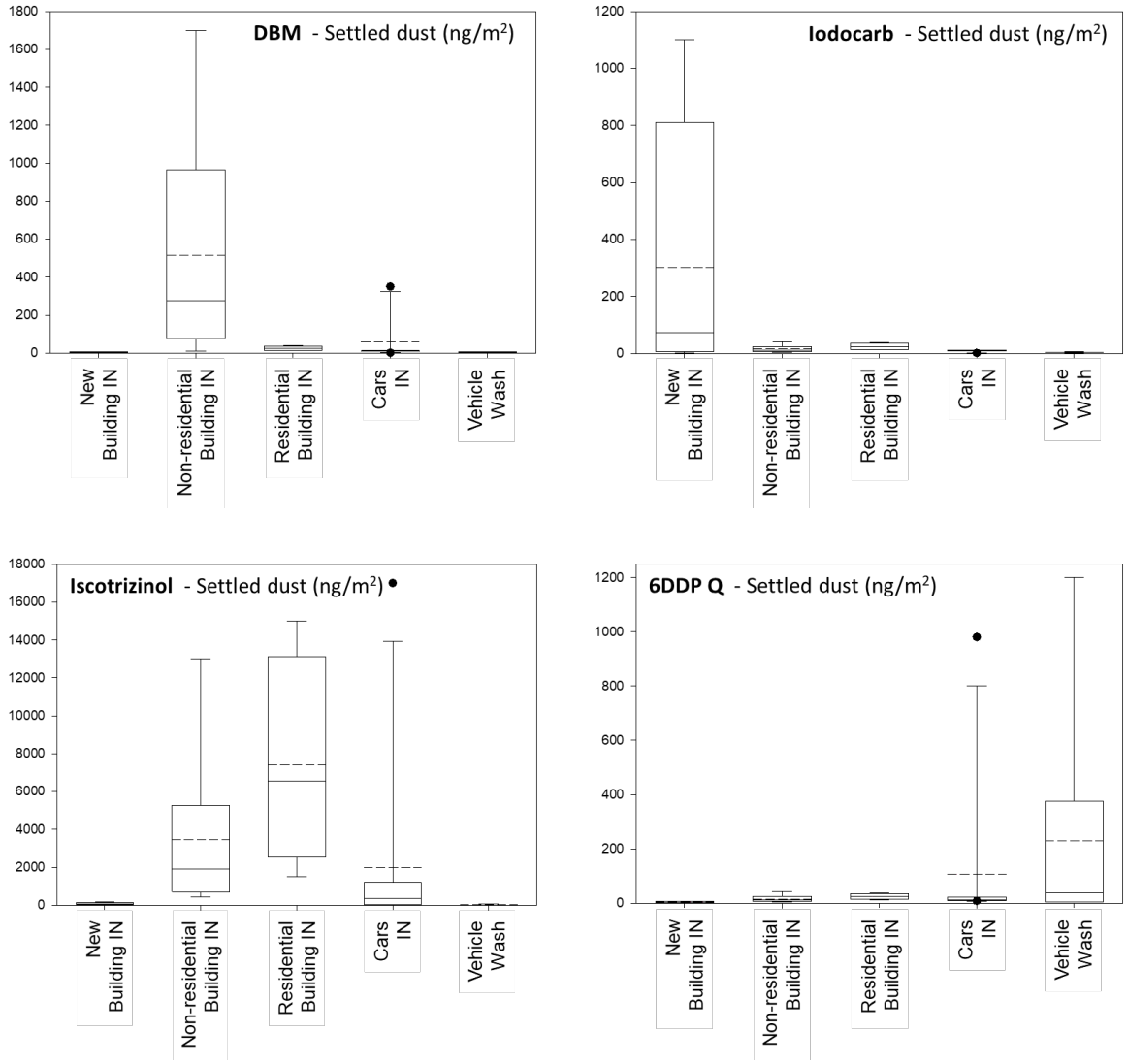


Figure 22: Box-plot of measured concentrations of DBM, Iodocarb, Iscotrizinol, and 6DDP-Q in settled dust (ng/m^2) at indoor sites from buildings, cars and vehicle washing facilities. The box-plots represents a range from 25-75% confidence interval with the center line representing the median concentrations, the dotted line the average concentrations and the error bars the outliers, respectively.

Iscitrizinol was detected in many samples and at high concentrations in residential and non-residential indoor environments as well as in the used cars (340-17 000 ng/m^2). In contrast, it was not detected in new cars and only in few of the newly constructed buildings and then at 100 times lower concentrations. Tinopal was detected at high concentrations in two of the non-residential

environments (1600-3000 ng/m^2), in two residential environments (140-750 ng/m^2) but in no other samples. Iodocarb was only detected in some of the newly constructed buildings (72-1100 ng/m^2) and DBM only in non-residential buildings and a few cars (100-1700 ng/m^2).

6DDP-Q was detected in all granule samples from artificial turfs with 10-1000 times higher concentrations in rubber granules (1900-2500 ng/g) than olive stones/sand (4.1-14 ng/g) and melted rubber flooring (2.1-110 ng/g). It was also detected in dust from rubber granule fields (indoors and outdoors) and from a few vehicle wash facilities and car retailers.

There is an emerging concern about the antioxidant/antiozonant 6PPD, which is added to polymers and tires to protect the products from degradation and weathering. However, the transformation product 6PPD-quinone is created when exposed to ozone. 6PPD or its degradations product can leach from tires, tire particles, or other 6PPD-containing polymers into the environment. A recent study have found acute toxicity effects of 6PPD-Q on the U.S Pacific Northwest coho salmon (*Oncorhyncus kisutch*), which lives in streams that receives road runoff and stormwater runoff (Tian, Zhao et al. 2021), however, other studies have so far not confirmed toxicity effects on any other aquatic species (Hiki, Asahina et al. 2021, McIntyre, Prat et al. 2021).

The presence of 6PPD-Q in rubber granulates (1900-2500 ng/g) from artificial rubber turfs show that there is a large potential for the 6-PPD-quinone to be leached from these granules over time and potentially enter the aquatic ecosystems with the runoff from these football fields. The screening results also demonstrate that untreated tunnel wash water can contain high levels of 6PPD-Q, which is released directly into freshwater or marine recipients in Norway. The 6PPD-Q levels found for both tunnel wash water and rubber granules are comparable to the levels found in the initial study by Tian et al. (2021), where the acute toxicity of coho salmon was demonstrated (1 300-1 800 ng/L). However, the concentrations reported in this screening can only be referred to as semi-quantitative, as no standard for 6PPD-Q was available at the time quantification. The 6PPD-Q was also detected at high levels in many of the samples coming from other matrices, such as the WWTP effluent water samples (50%, <10-160 ng/L), sediment from the marinas (40 %, <1 – 1 500 ng/g), in the vehicle wash (50%, <10 – 1 200 ng/m^2), and dust from artificial turfs (57 %, <23-110 ng/sample). This shows that tire particles and leachates coming from tires such as the 6PPD-Q are potentially being introduced to the environment both directly from road and tunnel runoff and indirectly by other areas where tire particles are exposed to the environment. To be able to assess the correct levels of 6PPD-Q in the Norwegian environment and potential toxicity effects towards Norwegian aquatic species such as Norwegian salmon, further investigations are needed.

3.7 Benzothiazoles

The concentration range, average, and detection frequency for the detected benzothiazole compounds are summarized in Table 31 and Table 32. The LoD for samples not found in any sample type are given in the complete data table in the Appendix.

3.7.1 Water, sludge, soil, sediment, and biota samples

Table 31: Concentration range, average, and detection frequency of benzothiazole compounds in water, sludge, sediment/soil, fish liver, and eggs.

	WWTP – Effluent	WWTP – Sludge	Alna river – Surface water	Marinas – Soil/Sed	Oslo fjord – Fish liver	Oslo fjord – Herring gull egg	Road tunnel – Wash water	Road tunnel – Sand trap
	ng/L	**ng/g dw**	**ng/L**	**ng/g dw**	**ng/g ww**	**ng/g ww**	**ng/L**	**ng/g dw**
ABTZ	13 – 24 18 100 %	<1 – 2,1 1,1 50 %	<10 – 37 16 90 %	<1 – 9,4 1,5 20 %	<1 - <1 0 %	<1 - <1 0 %	28 – 78 51 100 %	<1 – 4,1 2,0 67 %
MTBTZ	<10 - <10 0 %	<1 - <1 0 %	<10 - <10 0 %	<1 - <1 0 %	<1 - <1 0 %	<1 - <1 0 %	160 – 700 371 100 %	12 – 14 13 100 %
TBBS	<10 - <10 0 %	<1 - <1 0 %	<10 - <10 0 %	<1 - <1 0 %	<1 - <1 0 %	<1 - <1 0 %	<10 – 31 10 33 %	<1 - <1 0 %
PBTZ	<10 - <10 0 %	<1 – 1,5 0,88 50 %	<10 - <10 0 %	<1 – 1,2 0,57 10 %	<1 - <1 0 %	<1 - <1 0 %	20 – 520 129 100 %	8,9 – 27 17 100 %
CBS	<10 - <10 0 %	<1 - <1 0 %	<10 - <10 0 %	<1 - <1 0 %	<1 - <1 0 %	<1 - <1 0 %	<10 – 19 10 44 %	<1 - <1 0 %
HOBT	<10 - <10 0 %	17 – 310 172 100 %	<10 – 170 22 10 %	<1 – 53 10 20 %	<1 - <1 0 %	<1 - <1 0 %	410 – 2200 1349 100 %	14 – 110 46 100 %
UV-350	<10 - <10 0 %	<1 - <1 0 %	<10 – 11 5,6 10 %	<1 - <1 0 %	<1 - <1 0 %	<1 - <1 0 %	<10 - <10 0 %	<1 - <1 0 %
BTSA	<10 – 940 480 90 %	<1 – 4,1 1,8 50 %	<10 – 380 57 40 %	<1 – 20 3,7 30 %	<1 - <1 0 %	<1 - <1 0 %	4100 – 12000 6 790 100 %	28 – 98 70 100 %
MBT	<10 - <10 0 %	<1 – 5,7 3,4 90 %	<10 - <10 0 %	<1 – 7,6 2,9 60 %	<1 - <1 0 %	<1 - <1 0 %	8,9 – 87 26 100 %	1,4 – 4,9 3,8 100 %

Average: For the non-detects LoD/2 was used, when calculating the average.

2-(Methylthio)benzothiazole (MTBTZ), N-tert-butyl-2-benzothiazolesulfenamide (TBBS), N-cyclohexyl-2-benzothiazolesulfenamide (CBS), 2-mercaptobenzothiazole (MBT), benzothiazole (BTZ), 2-methylbenzothiazole (MBTZ), 2-aminobenzothiazole (ABTZ), 2-phenylbenzothiazole (PBTZ), 2-

benzothiazolinone (HOBT), and 2-benzothiazolesulfonic acid (BTSA) were frequently found in tunnel wash samples either in water or particles from the sand trap.
2-Mercaptobenzo thiazole (MBT), 2-aminobenzothiazole (ABTZ), 2-phenylbenzothiazole (PBTZ), 2-benzothiazolinone (HOBT), and 2-benzothiazolesulfonic acid (BTSA) were frequently found in sewage sludge from Bekkelaget WWTP and soil/sediment from boat winter storage or marinas.

ABTZ and BTSA were also detected in sewage effluent. ABTZ, HOBT, UV-350, and BTSA were also found in freshwater samples from Alna river. The highest concentration measured for ABTZ (37 ng/L), HOBT (170 ng/L), and BTSA (380 ng/L) are only slightly lower than freshwater PNEC registered in NORMAN (1 250/3 950/9 970 ng/L) (NORMAN 2021) (see also Table 47 in chapter 5).

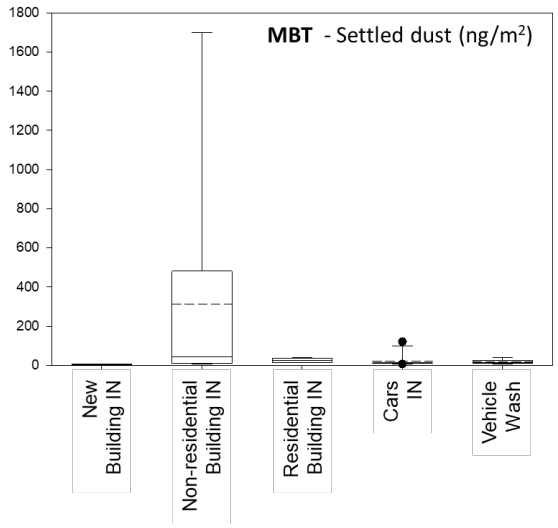
3.7.2 Granule, dust, and wipes samples

Table 32: Concentration range, average, and detection frequency of benzothiazole compounds in artificial turf granules, dust, and wipes.

	Vehicle wash – Wipes	Artificial turf – Granules	Artificial turf – Dust	Nonres. Building – Dust	Resid. Building – Dust	New building – Dust/Wipes	Cars – Wipes
	ng/m²	**ng/g**	**ng/sample**	**ng/m²**	**ng/m²**	**ng/m²**	**ng/m²**
BTZ	<110 - <240 0 %	<20 – 1400 272 60 %	<460 - <460 0 %	<160 - <1700 0 %	<540 - <1500 0 %	<78 - <270 0 %	<60 - <500 185 0 %
MBTZ	<110 - <240 0 %	<20 - <20 0 %	<460 - <460 0 %	<160 - <1700 0 %	<540 - <1500 0 %	<78 - <270 0 %	<60 – 2600 478 18 %
ABTZ	<6,9 – 7,4 5,0 17 %	<1 – 31 11 70 %	<23 - <23 0 %	<8 - <83 0 %	<27 - <77 0 %	<4 - <14 0 %	<3 - <25 0 %
MTBTZ	<5,7 - <12 0 %	1,1 – 160 66 100 %	<23 - <23 0 %	<8 – 120 34 11 %	<27 – 240 79 10 %	<4 - <14 0 %	<3 - <25 0 %
TBBS	<5,7 - <12 0 %	<1 – 31 7,6 70 %	<23 - <23 0 %	<8 - <83 0 %	<27 - <77 0 %	<4 - <14 0 %	<3 - <25 0 %
PBTZ	<6,9 – 14 6,1 17 %	<1 – 420 149 70 %	<23 - <23 0 %	<8 - <83 0 %	<27 - <77 0 %	<4 - <14 0 %	<3 – 66 15 9 %
CBS	<5,7 - <12 0 %	<1 – 22 4,8 70 %	<23 - <23 0 %	<8 - <83 0 %	<27 - <77 0 %	<4 - <14 0 %	<3 - <25 0 %
HOBT	<6,9 – 180 67 50 %	<1 – 1300 300 80 %	<23 - <23 0 %	<380 – 1000 570 67 %	<320 – 1200 643 40 %	<4 - <14 0 %	<17 – 360 67 36 %
BBIT	<5,7 - <12 0 %	<1 - <1 0 %	<23 - <23 0 %	<8 – 180 40 22 %	<27 – 100 41 10 %	<4 - <14 0 %	<3 - <25 0 %

	Vehicle wash – Wipes	Artificial turf – Granules	Artificial turf – Dust	Nonres. Building – Dust	Resid. Building – Dust	New building – Dust/Wipes	Cars – Wipes
	ng/m²	**ng/g**	**ng/sample**	**ng/m²**	**ng/m²**	**ng/m²**	**ng/m²**
MTBS	<5,7 – 42 11 17 %	<1 - <1 0 %	<23 - <23 0 %	<8 - <83 0 %	<27 - <77 0 %	<4 - <14 0 %	<3 - <25 0 %
Altax	<5,7 - <12 0 %	<1 – 26 7,4 80 %	<23 - <23 0 %	<8 – 81 26 11 %	<27 - <77 0 %	<4 - <14 0 %	<3 - <25 0 %
DTPB	<5,7 - <12 0 %	<1 – 2,4 0,89 30 %	<23 - <23 0 %	<8 - <83 0 %	<27 - <77 0 %	<4 - <14 0 %	<3 - <25 0 %
BTSA	<10 – 700 328 83 %	<1 – 79 37 70 %	<23 – 1100 308 57 %	<1160 – 8100 3 430 67 %	<1120 – 7300 2 600 40 %	<7 – 170 50 86 %	49 – 680 223 100 %
MBT	<10 – 39 17 83 %	<1 – 940 209 70 %	25 – 460 161 100 %	<13 – 1700 313 33 %	<27 - <77 0 %	<4 - <14 0 %	<12 – 120 20 27 %

Average: For the non-detects LoD/2 was used, when calculating the average.



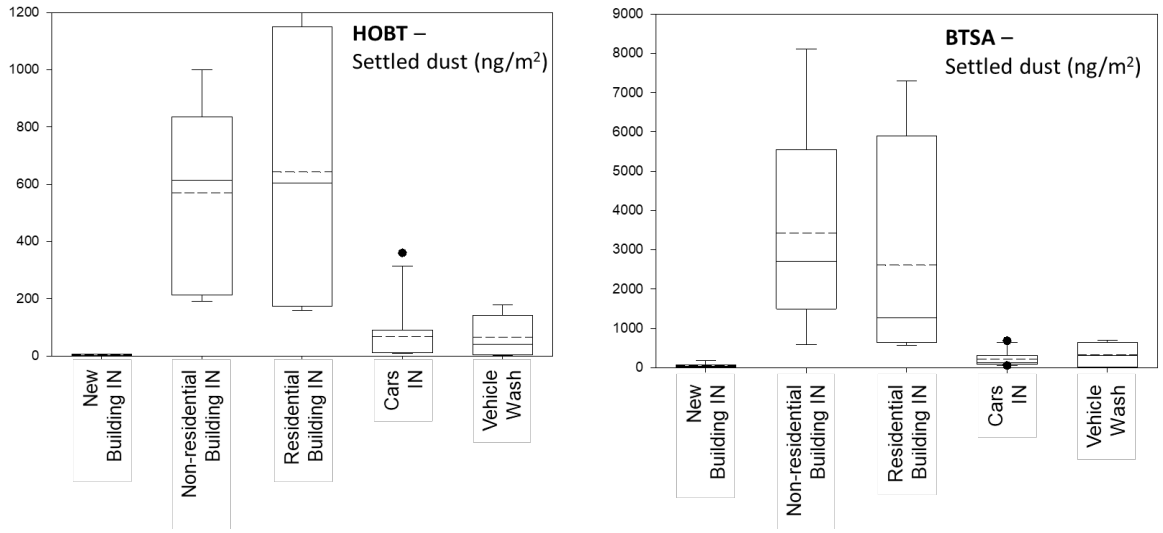


Figure 23: Box-plot of measured concentrations of the benzothiazole compounds MBT, HOBT, BTSA with high detection in settled dust (ng/m^2) at indoor sites from buildings, cars and vehicle washing facilities. The box-plots represents a range from 25-75% confidence interval with the center line representing the median concentrations, the dotted line the average concentrations and the error bars the outliers, respectively.

Of the benzothiazoles, MBT, HOBT, and BTSA were detected frequently in some of the dust samples from indoor related environments (i.e. vehicle wash, cars and non-residential). For MBT the highest concentrations were found in non-residential environments (45-1700 ng/m^2). For HOBT, and BTSA the highest concentrations were found in the existing residential and non-residential environments while the concentrations were significantly lower at the newly constructed/renovated sites. They were also detected in vehicle wash facilities and cars but at lower concentrations than the existing residential and non-residential sites. BTSA was found at higher concentrations and in more samples than HOBT. Both were generally 10-100 times higher than MBT in all samples.

The benzothiazoles BTZ, ABTZ, MTBTZ, PBTZ, TBBS, CBS, HOBT, Altax, and MBT were frequently detected in the granules from artificial turfs. All of these benzothiazoles were detected to highest frequency and at highest concentrations in rubber granules from indoor and outdoor football fields. The concentrations and detection frequencies were lower in the alternative fillings (olive stones/sand) and the melted rubber carpets.

3.8 Phenolic compounds

The concentration range, average, and detection frequency for the detected phenolic compounds are summarized in Table 33 and Table 34. The LoD for samples not found in any sample type are given in the complete data table in the Appendix.

3.8.1 Water, soil, and sediment samples

Table 33: Concentration range, average, and detection frequency of phenolic compounds in in water and sediment/soil.

	WWTP – Effluent	Alna river – Surface water	Marinas – Soil/Sed	Road tunnel – Wash water
	ng/L	**ng/L**	**ng/g dw**	**ng/L**
BHT	<170 – 430 220 70 %	<170 – 280 116 20 %	<36 – 150 57 50 %	<130 – 230 140 78 %
BHT-CHO	<120 - <120 0 %	<120 - <120 0 %	<110 – 390 110 30 %	<760 – 1200 568 22 %
BHT-COOH	<35 – 390 173 60 %	<35 – 99 48 70 %	<28 - <30 0 %	160 – 930 537 100 %
BHT-OH	<19 – 59 29 60 %	<19 - <19 0 %	<5,5 – 6 3,2 10 %	<48 – 48 27 11 %
BHT-Q	<710 - <710 0 %	<710 - <710 0 %	<90 – 1400 352 80 %	<690 – 950 569 56 %
DCP	<6,5 - <6,5 0 %	<6,5 - <6,5 0 %	<9,2 – 18 8,4 40 %	<14 - <15 0 %
TTBP	<0,1 - <0,1 0 %	<0,1 - <0,1 0 %	<0,4 – 6,1 1,1 30 %	<0,1 – 3,1 1,1 67 %
TBBC	<3,5 - <3,5 0 %	<3,5 - <3,5 0 %	<0,3 - <0,4 0 %	<2 - <5,7 0 %
VANOX	<0,1 - <0,1 0 %	<0,1 - <0,1 0 %	<19,4 – 9,7 9,7 10 %	<0,7 - <46 0 %
PTBP	<51 - <51 0 %	<51 – 65 29 10 %	<15 – 140 27 50 %	390 – 1000 820 100 %
24-DTBP	<2900 - <2900 0 %	<2900 – 3600 1 670 10 %	<270 – 730 323 40 %	<4300 – 5600 3 950 67 %
DtAP	<16 - <16 0 %	<16 – 24 11 20 %	<7,5 – 16 5,6 20 %	<42 - <44 0 %

	WWTP – Effluent	Alna river – Surface water	Marinas – Soil/Sed	Road tunnel – Wash water
	ng/L	**ng/L**	**ng/g dw**	**ng/L**
D8(HPS)	<5,3 – 8,2 3,2 10 %	<5,3 - <5,3 0 %	<1,9 – 6,3 1,5 10 %	6,9 – 40 26 100 %
BHT-quinol	<640 – 960 762 90 %	<640 – 860 658 70 %	<660 - <710 0 %	<1300 - <1400 0 %
EP	<14 – 48 20 70 %	<14 – 15 7,8 10 %	<56 - <60 0 %	<32 – 37 21 22 %
MP	<270 - <270 0 %	<270 - <270 0 %	<3,8 – 6,9 2,7 20 %	<5,1 - <5,4 0 %
PP	<7 – 10 4,2 10 %	<7 - <7 0 %	<7,2 - <7,6 0 %	<4,6 - <4,9 0 %
iPP	<7,7 – 13 4,8 10 %	<7,7 - <7,7 0 %	<0,4 - <0,4 0 %	<1,9 - <3 0 %
BenzP	<1 – 1,3 0,58 10 %	<1 - <1 0 %	<0,2 - <0,3 0 %	<1 - <1 0 %
MB-DTBP	<1 - <5,2 0 %	<37 – 170 43 20 %	<6,2 – 200 27 50 %	<53 – 1100 263 78 %
Fenozan	<760 - <760 0 %	<760 - <760 0 %	<1,1 – 140 27 20 %	<4000 - <4300 0 %
DTAHQ	<26 – 440 195 80 %	<26 - <26 0 %	<5,8 – 67 14 20 %	<24 – 270 82 33 %
26-DTBP	<980 - <980 0 %	<980 - <980 0 %	<2,2 – 3 33 30 %	<68 – 470 170 67 %

Average: For the non-detects LoD/2 was used, when calculating the average.

BHT, BHT-COOH, BHT-OH, D-8, HPS, BHT-quinol, and ethylparaben (EP) were very frequently found in the effluent samples of Bekkelaget WWTP. In surface freshwater samples from Alna river BHT, PTBP, 24-DTBP, DtAP, and BHT-quinol were detected from time to time and also quite high concentrations. In soil/sediment from boat winter storage/marinas BHT, BHT-CHO, BHT-OH, BHT-Q, DCP, TTBP, VANOX, PTBP, 24-DTBP, DtAP, and D8(HPS) were found in up to 50 % of all samples. In road tunnel run-off water, BHT, BHT-CHO, BHT-OH, BHT-Q, TTBP, PTBP, 24-DTBP, D8(HPS), and EP were found frequently. Several of these compounds might be endocrine disruptors. As illustrated below (chapter 5, Table 47 and Table 48) several of the antioxidants have maximum concentrations in both surface water and WWTP effluent close to or even above the lowest freshwater PNEC. For the antioxidants the maximum concentration in road tunnel wash water is exceeding the PNEC values. More than 10

antioxidants measured in soil/sediments from leisure boat marinas exceed the lowest PNEC for marine sediments. The potential environmental risk of these compounds both on the marine, terrestrial, and freshwater environment should be examined in more detail in dedicated studies.

3.8.2 Granule, dust, and wipes samples

Table 34: Concentration range, average, and detection frequency of phenolic compounds in artificial turf granules, dust, and wipes.

	Vehicle wash Wipes	Artificial turf Granules	Artificial turf Dust	Nonres. Building Dust	Resid. Building Dust	New building Dust/Wipes	Cars Wipes
	ng/m²	**ng/g**	**ng/sample**	**ng/m²**	**ng/m²**	**ng/m²**	**ng/m²**
BHT	<66 – 110 66 33 %	<51 – 870 202 60 %	<21 - <71 0 %	180 – 5300 922 100 %	80 – 3200 982 100 %	<8,7 – 85 35 71 %	<21 – 160 48 55 %
BHT-CHO	<10 – 170 36 17 %	<23 – 13000 2064 90 %	<34 - <110 0 %	<84 – 1200 265 44 %	<29 – 990 268 90 %	<10 – 86 30 43 %	<11 – 920 273 64 %
BHT-COOH	<3,6 - <8,1 0 %	<2,4 – 230 92 70 %	<5,9 - <20 0 %	<4,6 – 17 11 11 %	<2,6 - <48 0 %	<1,8 - <7,1 0 %	<1,9 – 350 47 36 %
BHT-OH	<10 - <23 0 %	<12 – 20 7,5 10 %	<15 - <50 0 %	<12 - <120 0 %	<4,9 - <120 0 %	<4,6 - <18 0 %	<4,9 - <33 0 %
BHT-Q	<67 - <410 0 %	<190 – 890 252 30 %	<73 – 180 69 14 %	<200 – 1700 534 78 %	<36 – 1200 338 60 %	<29 – 300 88 57 %	<50 – 520 243 82 %
DCP	<1,5 - <3,5 0 %	<1,6 - <1,9 0 %	<3,8 - <12 0 %	<2,9 – 530 74 44 %	<1,7 – 19 7,3 20 %	<1,2 - <4,5 0 %	<1,2 - <8,2 0 %
TTBP	<0,4 – 0,7 0,38 17 %	<1 – 2,3 0,82 20 %	<0,5 - <1,5 0 %	<2,3 – 8,9 3,4 89 %	<0,02 – 5,9 1,7 30 %	<0,2 – 25 3,8 43 %	<0,16 – 1,5 0,52 18 %
TBBC	<0,9 - <1,9 0 %	<1,2 - <1,5 0 %	<0,8 - <2,7 0 %	<0,64 – 32 4,7 22 %	<0,36 - <6,5 0 %	<0,26 - <0,98 0 %	<0,26 – 4,1 0,94 9 %
VANOX	<2,7 - <4,5 0 %	<3,5 – 67 8,4 10 %	<0,1 – 2,3 1,1 43 %	<0,06 – 32 7,5 89 %	0,79 – 28 11 100 %	<0,02 – 140 22 71 %	<0,02 – 11 3,4 91 %
PTBP	<41 - <73 0 %	<15 – 1800 221 60 %	<47 - <160 0 %	<37 - <380 0 %	<21 - <380 0 %	<19 - <56 0 %	<15 - <100 0 %
24-DTBP	<230 – 1200 510 17 %	<140 – 960 349 80 %	<250 - <810 0 %	<210 – 2500 649 22 %	<120 – 4500 1144 40 %	<100 – 160 109 29 %	<80 – 2900 543 45 %
DtAP	<6,4 - <14 0 %	<4,9 – 1500 202 30 %	<9,3 - <31 0 %	<7,2 – 37 18 11 %	<4,2 – 4 13 10 %	<2,8 – 56 10 14 %	<3 - <20 0 %
D8(HPS)	<1 – 8,2 2,2 33 %	<1,6 - <1,7 0 %	<0,9 - <3 0 %	3,8 – 54 18 100 %	<2,4 – 61 11 70 %	<0,5 – 1,1 0,57 29 %	<1,3 – 15 5,1 64 %

	Vehicle wash Wipes	Artificial turf Granules	Artificial turf Dust	Nonres. Building Dust	Resid. Building Dust	New building Dust/Wipes	Cars Wipes
	ng/m²	**ng/g**	**ng/sample**	**ng/m²**	**ng/m²**	**ng/m²**	**ng/m²**
BHT-quinol	<92 – 800 206 17 %	<110 – 25000 2873 70 %	<380 - <1300 0 %	<300 – 1200 716 11 %	<170 – 200 529 10 %	<120 - <460 0 %	<120 - <830 0 %
TBHQ	<210 - <460 0 %	<170 – 11000 1190 10 %	<200 - <660 0 %	<160 - <1600 0 %	<83 – 1700 357 10 %	<61 - <240 0 %	<65 - <430 0 %
EP	<4,2 – 74 17 50 %	<2,1 – 40 12 80 %	<7 - <23 0 %	<19 – 1200 183 89 %	15 – 230 80 100 %	<2,2 – 51 12 71 %	<9,1 – 190 43 73 %
MP	<2,8 - <6,1 0 %	<1,7 – 18 3,4 30 %	<5,3 - <18 0 %	<13 – 310 50 67 %	<2,4 – 85 23 70 %	<1,6 – 8,7 2,5 14 %	<1,7 – 37 9,6 18 %
PP	<0,5 - <1,4 0 %	<1 – 5,3 1,0 10 %	<0,6 - <1,9 0 %	<0,82 – 370 48 44 %	2,7 – 100 34 100 %	<0,18 - <0,7 0 %	<0,56 – 0,95 0,52 9 %
iPP	<0,5 - <1,4 0 %	<1,2 - <1,4 0 %	<0,5 - <1,7 0 %	<0,4 - <4,1 0 %	<0,24 - <4 0 %	<0,16 - <0,6 0 %	<0,16 - <1,1 0 %
BuP	<0,5 - <1,4 0 %	<0,6 – 3,5 0,67 10 %	<0,7 - <2,3 0 %	<1,9 – 36 6,1 78 %	<0,94 – 12 3,9 70 %	<0,22 – 0,89 0,31 14 %	<0,24 – 4,2 1,5 36 %
iBuP	<0,7 - <1,7 0 %	<0,8 - <1 0 %	<0,9 - <2,8 0 %	<0,68 - <6,9 0 %	<0,4 – 1,4 1,3 10 %	<0,26 - <1 0 %	<0,28 - <1,9 0 %
BenzP	<0,5 – 0,4 0,48 17 %	<0,3 – 3,3 0,47 10 %	<0,1 - <0,3 0 %	<0,08 – 0,3 0,18 11 %	<0,04 - <0,76 0 %	<0,04 – 0,87 0,18 29 %	<0,04 - <0,2 0 %
MB-DTBP	<12 – 110 25 17 %	<9,9 – 77000 23021 90 %	<17 - <57 0 %	<24 – 260 57 33 %	<7,9 – 210 37 10 %	<5,3 – 220 42 29 %	<5,6 – 200 52 55 %
MB-ETBP	<0,9 - <2 0 %	<1,1 – 220 26 40 %	<1,6 - <5,2 0 %	<1,2 - <13 0 %	<0,72 - <13 0 %	<0,5 - <1,9 0 %	<0,52 - <3,5 0 %
Fenozan	<3,6 - <8,1 0 %	<2,5 – 610 157 70 %	<6 - <20 0 %	<4,7 - <48 0 %	<2,7 - <48 0 %	<1,9 - <7,2 0 %	<1,9 – 57 11 27 %
DTAHQ	<34 - <74 0 %	<11 – 780 152 40 %	<37 - <120 0 %	<100 – 7100 923 56 %	<32 – 2000 547 90 %	<11 – 91 30 43 %	<12 – 170 52 27 %
26-DTBP	<4,7 - <17 0 %	<8 – 230 48 70 %	<2,2 – 3,8 1,9 14 %	<5,6 – 160 30 67 %	1,8 – 83 16 100 %	<0,9 – 4,1 1,8 57 %	<2,1 – 560 91 91 %

Average: For the non-detects LoD/2 was used, when calculating the average.

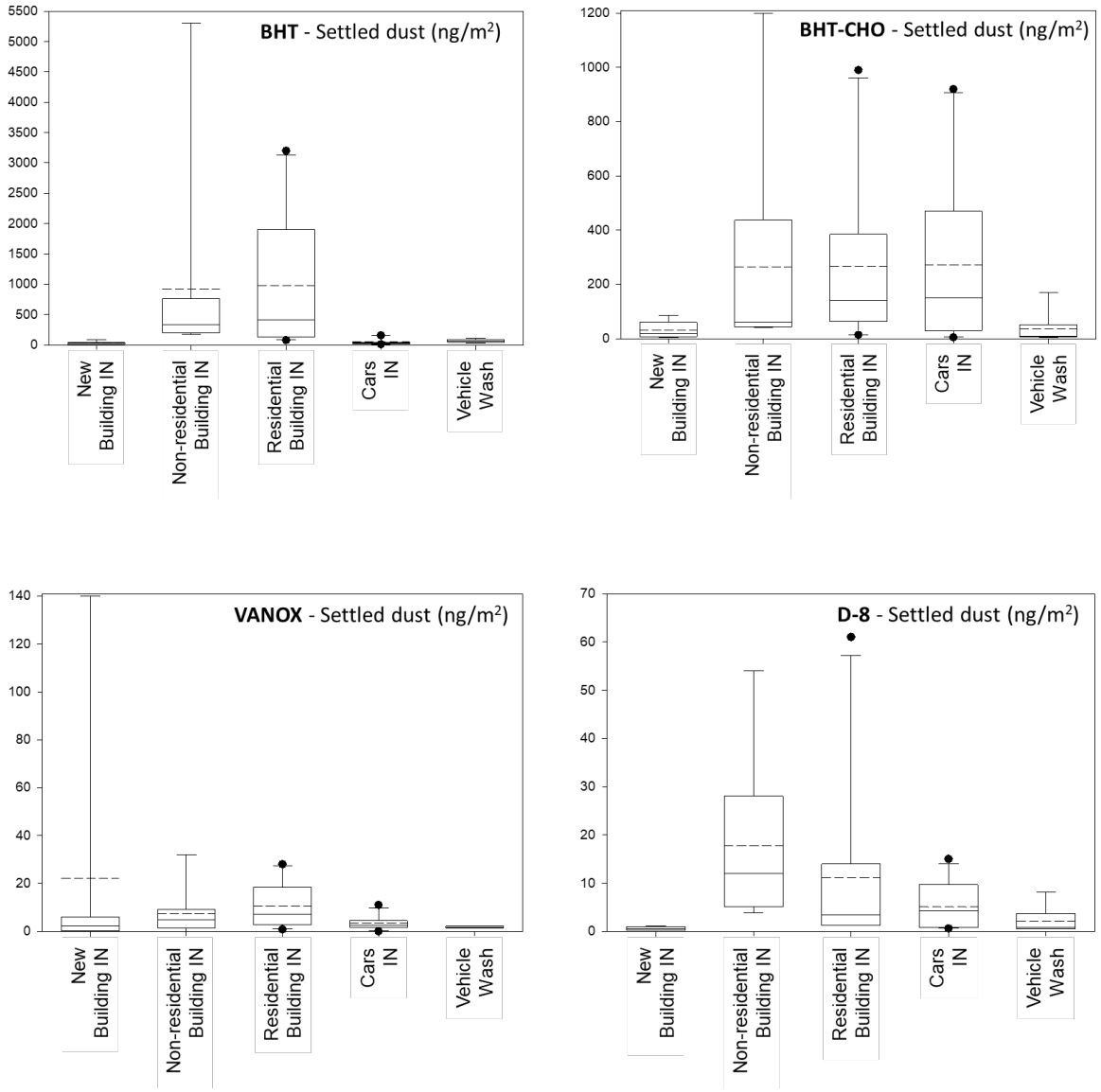


Figure 24: Box-plot of measured concentrations of four priority phenolic compounds with high detection in settled dust (ng/m^2) at indoor sites from buildings, cars and vehicle washing facilities. The box-plots represents a range from 25-75% confidence interval with the center line representing the median concentrations, the dotted line the average concentrations and the error bars the outliers, respectively.

Four of the priority phenols were not detected or detected to low extent in indoor related matrices (i.e. BHT-OH, TBBC, PTBD and 3-BHA). PTBA was however detected in granules from artificial turfs and the highest concentrations were found in the indoor football fields (10-100 times higher than at the outdoor fields). Higher concentrations in granules from indoor than outdoor football fields were also observed for most of the analysed BHT-compounds. The highest concentrations in granules were found for BHT-CHO and BHT-quinol. Highest concentrations and most compounds detected were found in rubber granules from normal artificial turfs while the phenols were not detected or detected in lower concentrations in the olive stone /sand filling of alternative artificial turfs.

The highest concentrations of the priority phenols in dust were found for BHT-compounds (i.e. BHT, BHT-CHO, BHT-Q) and 24-DTBP. For all of them the highest concentrations were found in residential and non-residential dust while the concentrations were significantly lower in the newly constructed/renovated indoor sites. The same was observed for other phenols detected at lower concentrations (e.g. D-8, DCP and VANOX (excl. one outlier)).

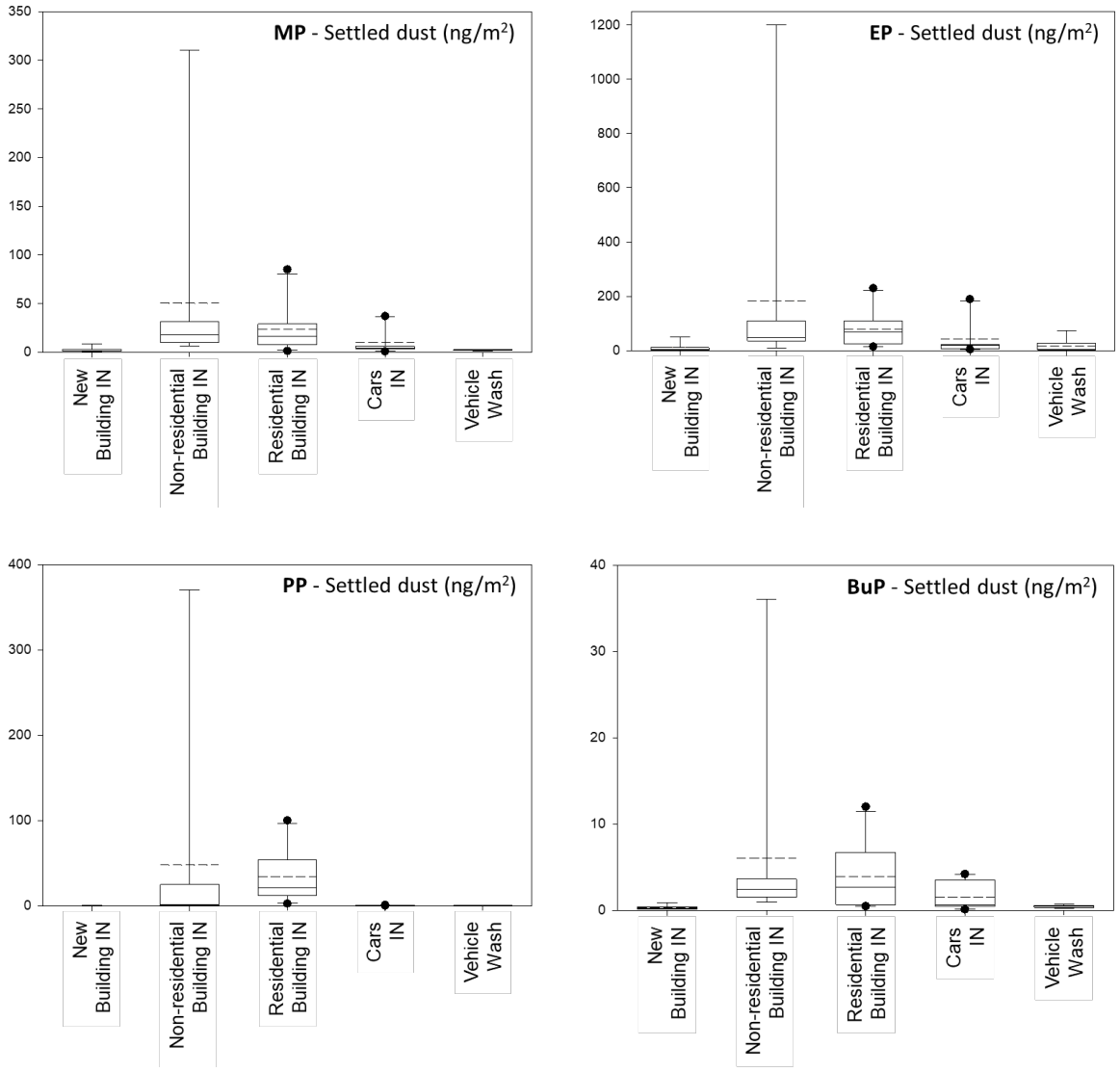


Figure 25. Box-plot of measured concentrations of four parabens (methyl-, ethyl-, propyl, and butylparaben) with high detection in settled dust (ng/m^2) at indoor sites from buildings, cars and vehicle washing facilities. The box-plots represents a range from 25-75% confidence interval and the median concentrations, the average concentrations and the error bars.

Four of the seven targeted parabens (EP, MP, PP and BuP) were frequently detected in the indoor-related matrices. The highest concentrations were found for EP followed by MP and PP. One non-residential site (playland) stood out with elevated levels of all the four parabens. Excluding this site, the detected concentrations were in the same range at the non-residential and residential sites. The concentrations were significantly lower at the newly constructed/renovated sites as well as at the vehicle washing facilities and for all but BuP also in car samples.

3.9 Surfactants

The concentration range, average, and detection frequency for the detected surfactants are summarized in Table 35 and Table 36. The LoD for samples not found in any sample type are given in the complete data table in the Appendix.

3.9.1 Water, sludge, soil, sediment, and biota samples

Table 35: Concentration range, average, and detection frequency of surfactant compounds in water, sludge, and blue mussels (ng/g w.w).

	WWTP – Effluent	WWTP – Sludge	Alna river – Surface water	Marinas – Soil/Sed	Marinas – Blue mussel	Road tunnel – Wash water	Road tunnel – Wash water
	ng/L	**ng/g dw**	**ng/L**	**ng/g dw**	**ng/g ww**	**ng/L**	**ng/g dw**
DDDA	<100 - <100 0 %	<50 – 320 181 70 %	<100 - <100 0 %	<50 – 1400 163 10 %	<50 - <50 0 %	<100 - <100 0 %	<50 - <50 0 %
DHDA	<500 - <500 0 %	660 – 1200 964 100 %	<500 - <500 0 %	<250 - <250 0 %	<250 - <250 0 %	<500 - <500 0 %	<250 - <250 0 %
DTDA	<100 - <100 0 %	860 – 2000 1 490 100 %	<100 - <100 0 %	<50 - <50 0 %	<50 - <50 0 %	<100 - <100 0 %	<50 - <50 0 %
DOA	<100 - <100 0 %	<50 - <50 0 %	<100 - <100 0 %	<50 - <50 0 %	<50 - <50 0 %	<100 - <100 0 %	<50 – 130 84 67 %

Average: For the non-detects LoD/2 was used, when calculating the average.

The tree surfactant compounds DDDA, DHDA, and DTDA were found in nearly all samples of sewage sludge, and DOA was found in sand trap samples from the road tunnel wash. None of the selected surfactants could be detected in effluent, surface, and tunnel wash water, nor biota.

3.9.2 Granule, dust, and wipes samples

Table 36: Concentration range, average, and detection frequency of surfactant compounds in artificial turf granules, dust, and wipes.

	Vehicle wash – Wipes	Artificial turf – Granules	Artificial turf – Dust	Nonres. Building – Dust	Resid. Building – Dust	New building – Dust/Wipes	Cars – Wipes
	ng/m²	**ng/g**	**ng/sample**	**ng/m²**	**ng/m²**	**ng/m²**	**ng/m²**
DTDA-oxide	<35 – 7400 1 880 67 %	<50 - <50 0 %	<1200 - <1200 0 %	<108 – 3300 759 67 %	<140 – 460 226 20 %	<20 – 330 93 71 %	<30 – 130 53 18 %
DDDA-oxide	<35 – 18000 4 080 50 %	<50 - <50 0 %	<1200 - <1200 0 %	<660 – 18000 4 020 67 %	<640 – 2100 1 190 40 %	<20 – 1500 445 71 %	<86 – 2400 302 36 %
DDDA	<35 – 870 249 33 %	<50 - <50 0 %	<1200 - <1200 0 %	<190 – 780 356 44 %	<140 - <390 0 %	<20 – 120 34 14 %	<15 – 650 164 27 %
DTDA	<35 – 410 119 33 %	<50 - <50 0 %	<1200 - <1200 0 %	<39 - <420 0 %	<140 - <390 0 %	<20 - <68 0 %	<15 - <130 0 %
DDA-oxide	<28 – 92 32 17 %	<50 - <50 0 %	<1200 - <1200 0 %	<39 - <420 0 %	<140 - <390 0 %	<20 – 36 22 14 %	<15 - <130 0 %

Average: For the non-detects LoD/2 was used, when calculating the average.

Four of the priority surfactants compounds, were not detected in any of the indoor related samples (i.e. DHDA, DDOA, DOA and DODA). Two of the priority surfactant compounds were detected occasionally in car wash samples and one of the new buildings (i.e. DDA-oxide and DTDA) and three were detected in all of the indoor-related matrices (i.e. DTDA-oxide, DDDA-oxide, and DDDA). None of the surfactants were detected in granules or dust from artificial turfs. The highest concentrations were found for DDDA-oxide in vehicle wash (<35-18000 ng/m^2) and non-residential indoor environments (<660- 18000 ng/m^2). One non-residential sample (playland) had ten times higher concentrations than the other non-residential sites. The surfactants were detected at high concentrations at the car washing facilities but not at all or at very low concentrations at the bus washing facilities. The detected surfactants were lower in dust/wipes samples from newly renovated/constructed buildings than from existing buildings.

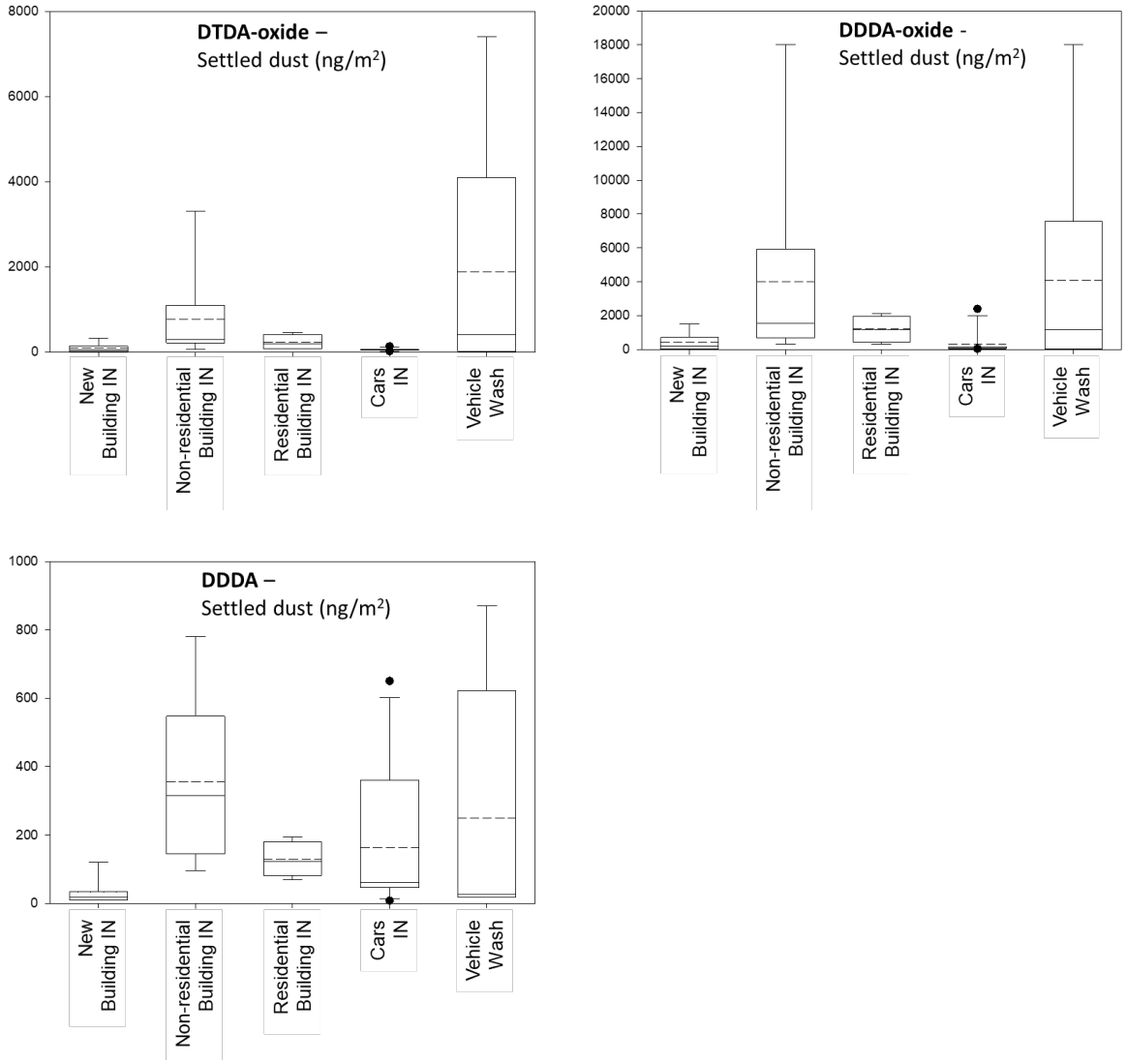


Figure 26: Box-plot of measured concentrations of three surfactant compounds with high detection in settled dust (ng/m^2) at indoor sites from buildings, cars and vehicle washing facilities. The box-plots represents a range from 25-75% confidence interval with the center line representing the median concentrations, the dotted line the average concentrations and the error bars the outliers, respectively.

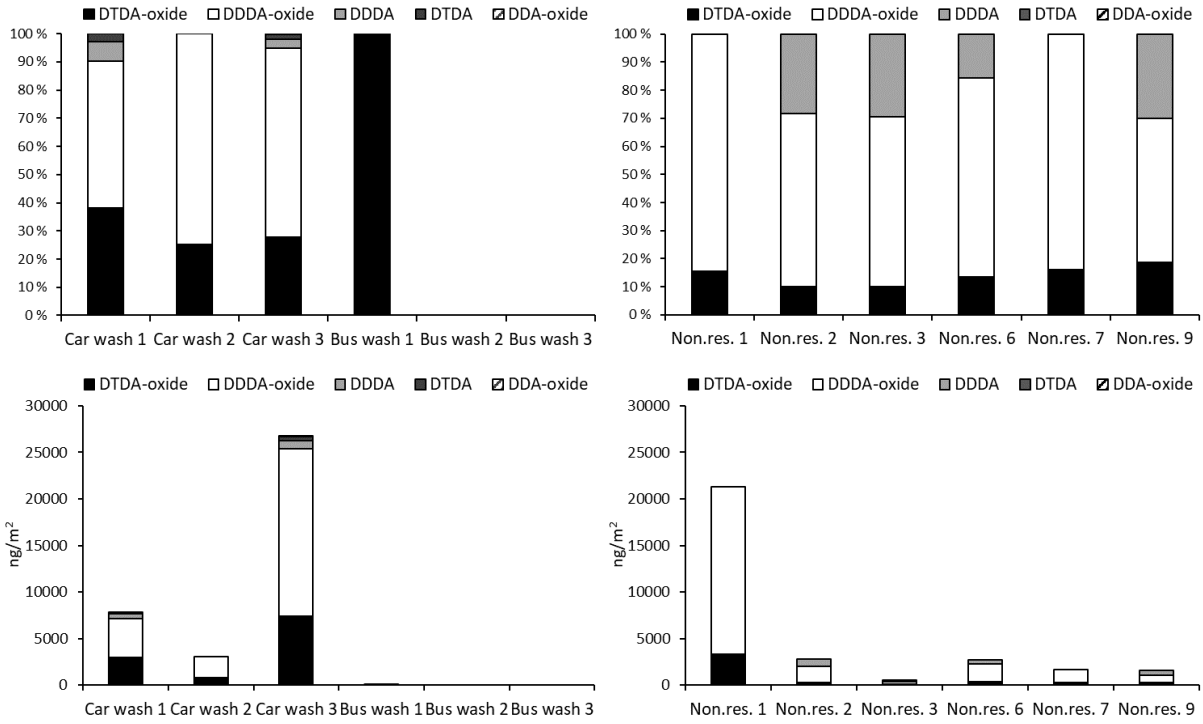


Figure 27: Compositional profiles of detected surfactants in settled dust samples from vehicle wash facilities (cars and buses) and non-residential indoor environments.

3.10 Plastic polymer and additive analysis

The results from the various pyr-GC-MS are summarized in Table 37. Several different analyses were performed on the samples including double shoot analysis with the aim to be able to semi quantitative detect the same compounds related to plastic and rubber usage. For this analysis we used an approach based on suspect screening including known mass fragments for volatile compounds (3.1), Dechloranes (3.4) and plasticizers (3.5). This resulted unfortunately not in any hits for these plastic and rubber related compounds due to the small sample amount resulting in a relatively high LoD for these specific compounds. The pyr-GC-MS allows sample amount up to a few mg, which is sufficient for extracted microplastics or pure polymers in case of the artificial turf granulates, but not for environmental samples. In addition, pyr-GC-MS of environmental samples often result in high background contamination and the sample is split before GC injection, again resulting in higher LoDs. Improved and more specific databases for additives are currently developed and will improve the LoD for a combined analysis. However, targeted analysis for the specific compounds (presented in 3.1, 3.4 and 3.5) currently is still the only way to search for these polymer related compounds. The concentration range, average, and detection frequency for the detected polymers and rubber compounds are summarized in **Error! Reference source not found.**

Table 37: Concentration range, average, and detection frequency of plastic and rubber polymer related compounds in WWTP-Effluent, WWTP-Sludge and river sediment from the Alna river, all normalised to (ug/mg).

	Artificial turf – Granules	WWTP – Sludge	River Sediment
	µg/mg	**µg/mg**	**µg/mg**
SBR+BR	183 – 313 258 100%	8 – 13 8 100%	0.6 – 6.4 3 100%
PVC	NA 0%	0.4 – 1.5 1 100%	4 -11 8 100%
PE	NA 0%	28 – 57 36 100%	< 0.2 – 0.15 0.15 17%
PET	NA 0%	1.3 – 8.1 4.0 100%	0.3 - 0.13 0.13 100%
PA	NA 0%	0.1 – 0.9 0.2 100%	45 – 144 95 100%
PS	NA 0%	217 – 1530 476 100%	0.1 – 28 6 100%

The results of the pyr-GC-MS analysis confirm the sources of several of the other compounds analysed with target analysis and additives to rubber are found in the artificial turf granulates, and the additives to polymers were found in WWTP- sludge and river sediment where also several micro plastics were found. High levels of polyamide (nylon) microplastics was found in river sediment, polyamide is the most used fibre in clothing but also used in several other applications including ropes and fishing gear. The density of polyamide is large than water (1.13 g/ml) and thus accumulates in river sediment.

4 Site specific contamination pattern

4.1 Traffic related contaminants

There are several sample types and sampling sites in this project that are closely linked to traffic related contaminants. The Alna river is collecting surface water from the area around E6 and other main roads in the Alna valley. Both Breivoll and Kværner sampling site are located downstream this area. The road tunnel washing samples (water/sediment) are either related to car traffic, either from the vehicles itself or from the road pavement or the tunnel ceiling, or to cleaning products used during this washing. Most of the artificial turf filling granules are made from used car tires. The compounds found in vehicle washing facilities are either from the vehicles washed or from the cleaning products used. Finally, there are wipes taken inside cars. These samples are showing different pathways from traffic as a pollution source into the environment, and in Table 38 and Table 39 compounds are shown, which are found in more than one of these sample types. Only compounds are listed with a combined detection frequency higher that 50 %. That is of course not a final proof that these compounds are emitted by traffic, but a good indication.

Table 38: Detection frequency of compounds commonly found in traffic related samples with priority compounds given in bold (VOC, SVOC, Dec, and Plasticiser). Only compounds shown with an average detection frequency higher than 40%.

Sample description	Benzene	Toluene	m+p-Xylene	o-Xylene	**α-Pinene**	Styrene	β-Pinene	135-TMBz	**3-Carene**	124-TMBz	Limonene	**p-Cymene**	123-TMBz	**Lilial**	**isoTAC**	**TAC**	Dpsyn	Dpanti	DEHP	DiNP	DiDP	TEHP
	VOC														**SVOC/Dec/Plasticiser**							
Alna river	100	100	100	90	90	0	90	90	90	90	90	80	90	50	100	100	na	na	30	10	90	0
Tunnel wash water	44	89	67	67	78	89	67	67	67	67	67	67	56	44	100	89	na	na	67	67	100	56
Tunnel wash sediment	na	na	na	na	na	na	na	na	na	na	na	na	na	na	0	0	67	100	na	na	na	na
Vehicle wash	100	100	100	100	100	100	100	100	100	100	100	100	100	100	60	0	67	83	100	100	83	83
Artificial turf	100	100	100	90	100	100	100	90	90	90	90	90	90	100	10	0	na	na	80	70	0	70
Cars interior	100	100	100	100	100	100	100	100	100	100	100	100	100	69	100	18	27	36	91	82	91	64

Table 39: Detection frequency of compounds commonly found in traffic related samples with priority compounds given in bold (SDPA, LC-MS, BTZ, and Phenols). Only compounds shown with an average detection frequency higher than 40%.

Sample description	tBuDPA	DtBuDPA	diAMS	DitOcDPA	DBM	6PPD Q	BTZ	ABTZ	MTBTZ	PBTZ	HOBT	BTSA	MBT	BHT	BHT-CHO	BHT-COOH	24-DTBP	D8(HPS)	MB-DTBP	26-DTBP
	SDPA				**LC-MS/BTZ**									**Phenols**						
Alna river	0	0	0	0	0	10	0	90	0	0	10	40	0	20	0	70	10	0	20	0
Tunnel wash water	100	100	100	100	0	100	0	100	100	100	100	100	100	78	22	100	67	100	78	67
Tunnel wash sediment	100	100	100	100	100	100	67	67	100	100	100	100	100	na	na	na	na	na	na	na
Vehicle wash	17	17	17	50	0	50	0	17	0	17	50	83	83	33	17	0	17	33	17	0
Artificial turf	60	60	50	60	0	100	60	70	100	70	80	70	70	60	90	70	80	0	90	70
Cars interior	18	18	0	18	18	18	0	0	0	9	36	100	27	55	64	36	45	64	55	91

Aromatic VOCs as benzene and benzene derivatives were ubiquitous in all these sample types and might come from fuel and exhaust, solvents in car polish and similar sources (Table 38 and Figure 28). Fragrances such as α-pinene, β-pinene, 3-carene, limonene, p-cymene, and Lilial were also ubiquitous in all these sample types, however, as shown in Figure 28, more prominent in vehicle wash and car interiors than artificial turf. Figure 26 also shows that the measured concentrations and the composition of the analyzed VOC differs between artificial turfs and cars and vehicle was sites.

Vulcanization agents as ATBZ, MTBTZ, PBTZ, HOBT, BTSA, MBT, and 6PPD-Q dominated the samples from road tunnel wash, artificial turf, and were in some cases also found in surface water. Also, antioxidants of the SDPA type dominated the samples from road tunnel wash, and artificial turf. Whereas antioxidants of the hindered phenol type (BHT and BHT derivatives), plasticizers (DEHP, DiNP, and DiDP), and flame retardants DPsyn/anti) might be more pronounced in car interior.

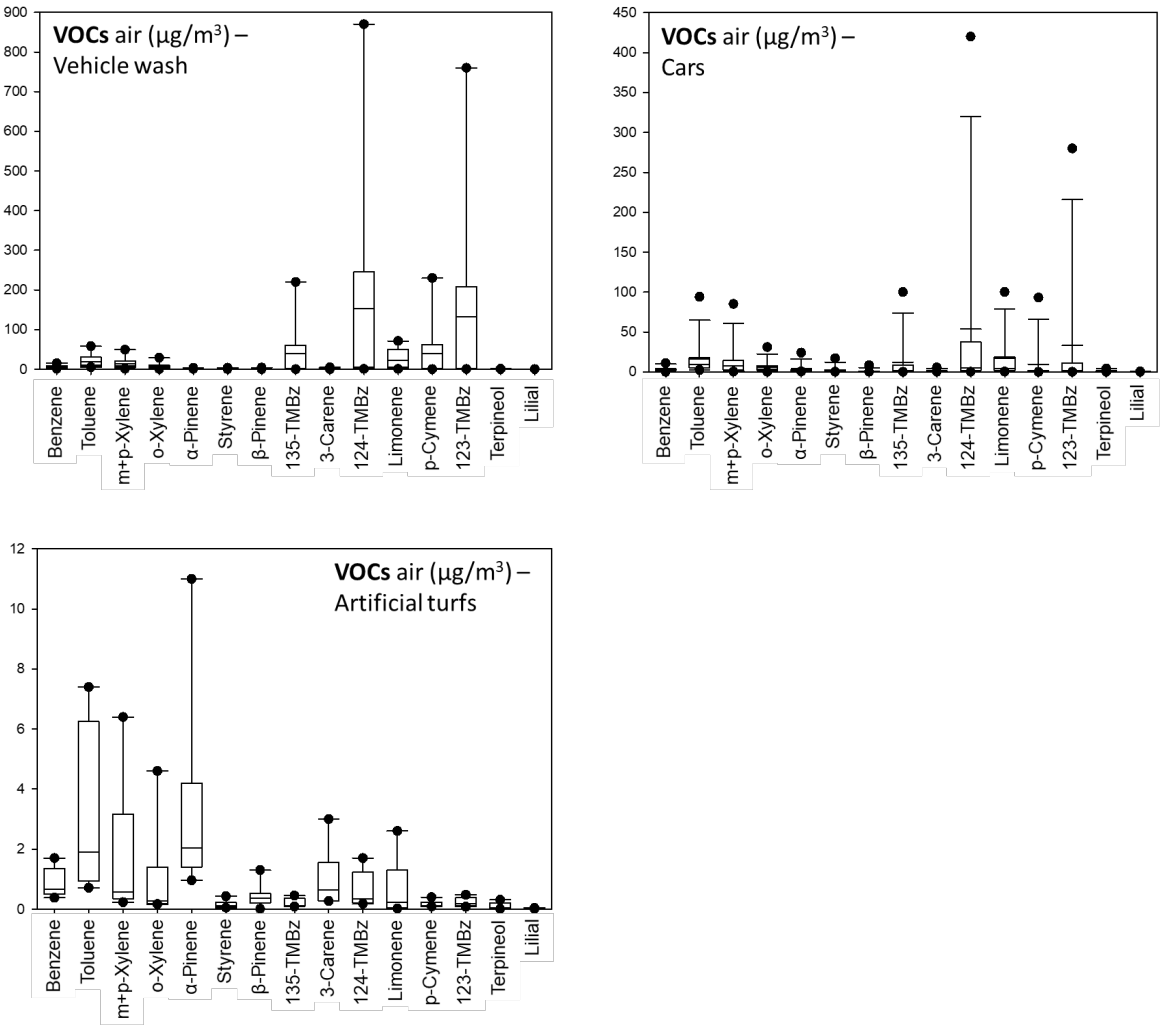


Figure 28: Composition and concentrations of VOCs in air (µg/m³) at vehicle wash facilities, cars and artificial turfs.

Many of highest values in this data set are related to storm water events and the re-mobilization of settled or sedimented pollution. In the case of a follow-up of these findings, the timing of the surface water sampling should consequently be discussed in detail to cover special situations like snow-melting and other storm water events in an optimal way.

4.2 Contaminants emitting to the fjord

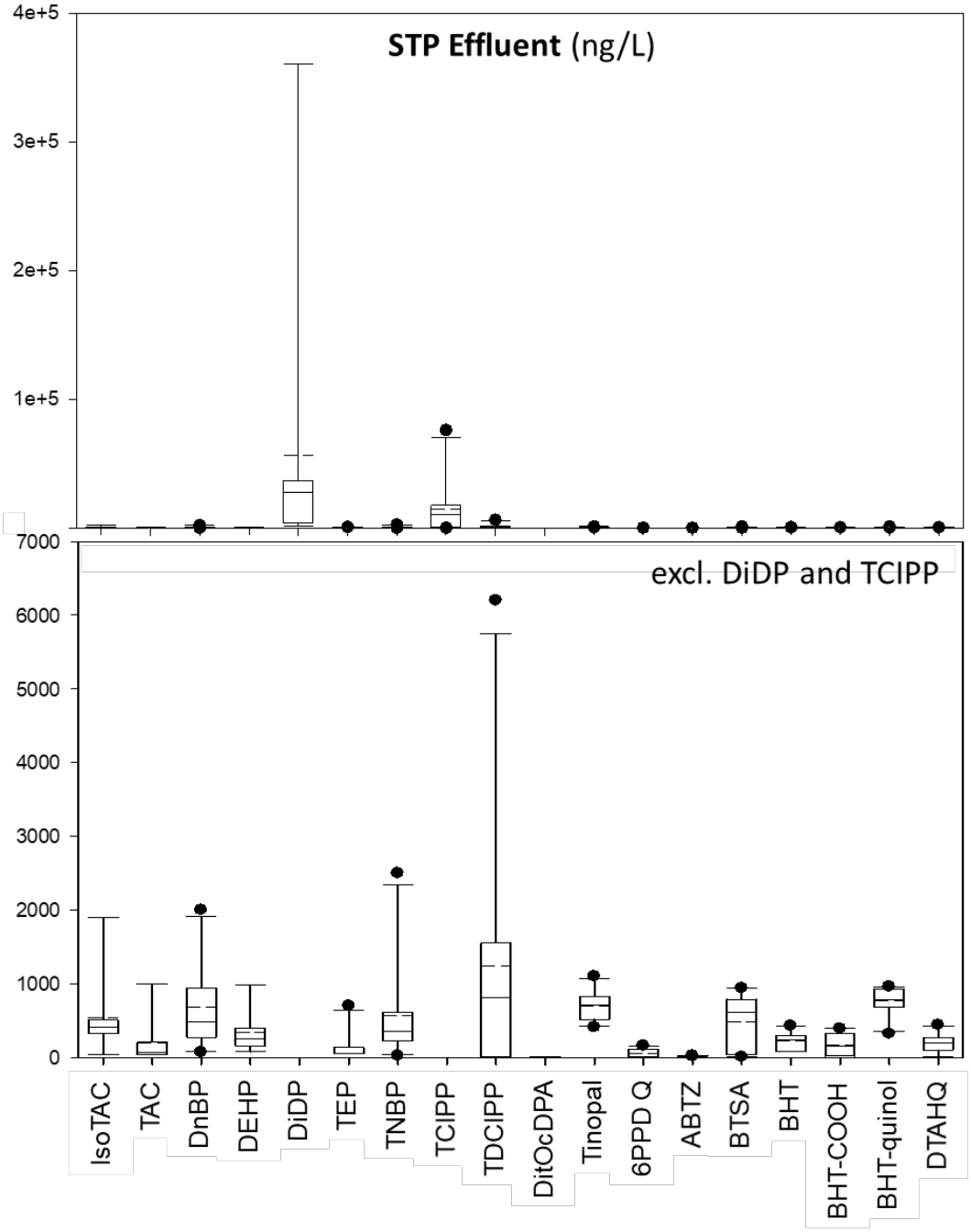
Effluent from Bekkelaget WWTP and surface water from Alna river go straight to the Oslofjord. Soil samples from the surface soil of winter boat storage sites together with sediments from these harbours or marinas also leak contaminants directly into Oslofjord. Contaminants measured in those sample types are thus polluting the Oslofjord and of concern for the marine life and environment. Compounds commonly found in these sample types are shown with their detection frequency in Table 40.

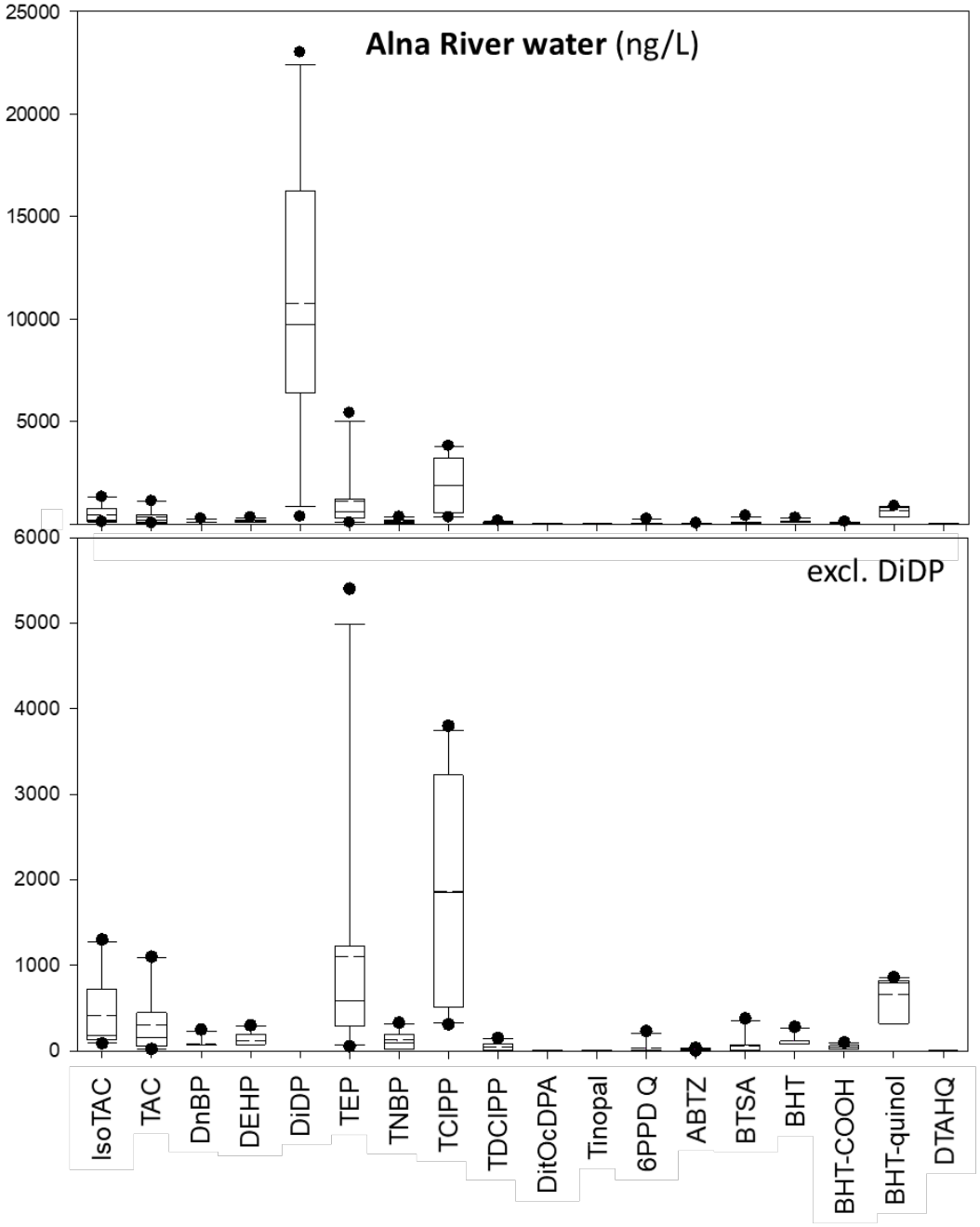
Table 40: Detection frequency (%) of compounds commonly found in samples related to the marine environment). Only compounds shown with an average detection frequency higher than 30%.

Sample description	isoTAC	TAC	Dpsyn	Dpanti	DnBP	DEHP	DiDP	TEP	TNBP	TCIPP	TDCIPP	DitOcDPA	Tinopal	6PPD Q	ABTZ	BTSA	BHT	BHT-COOH	BHT-quinol	DTAHQ
WWTP – Effluent	90	90	na	na	90	70	90	30	90	90	50	0	100	50	100	90	70	60	90	80
Alna river water	100	100	na	na	10	30	90	90	70	100	40	0	0	10	90	40	20	70	70	0
Marina – Soil/sediment	0	0	50	100	30	40	0	0	0	0	0	100	0	40	20	30	50	0	0	20

The crosslinker/vulcanization agents isoTAC and TAC were very frequently found in both effluent for Bekkelaget WWTP and surface water of Alna river. The measured concentrations are high and close to freshwater PNEC (see chapter 3.3.1), which justify a closer follow-up of these compounds.

DPsyn and DPanti were not analyzed in water samples but were regularly found in soil and sediment samples of marinas. The plasticizers and flame retardants DnBP, DEHP, DiDP, TEP, TNBP, TCIPP, and TDCIPP were regularly found in both effluent from Bekkelaget WWTP and surface water from Alna river, which shows the importance of water as a pathway for these contaminants.


STP Effluent (ng/L)
4e+5
3e+5
2e+5
1e+5
7000
excl. DiDP and TCIPP
6000
5000
4000
3000
2000
1000
0
IsoTAC
TAC
DnBP
DEHP
DiDP
TEP
TNBP
TCIPP
TDCIPP
DitOcDPA
Tinopal
6PPD Q
ABTZ
BTSA
BHT
BHT-COOH
BHT-quinol
DTAHQ


Alna River water (ng/L)
excl. DiDP
25000
20000
15000
10000
5000
6000
5000
4000
3000
2000
1000
0
IsoTAC
TAC
DnBP
DEHP
DiDP
TEP
TNBP
TCIPP
TDCIPP
DitOcDPA
Tinopal
6PPD Q
ABTZ
BTSA
BHT
BHT-COOH
BHT-quinol
DTAHQ

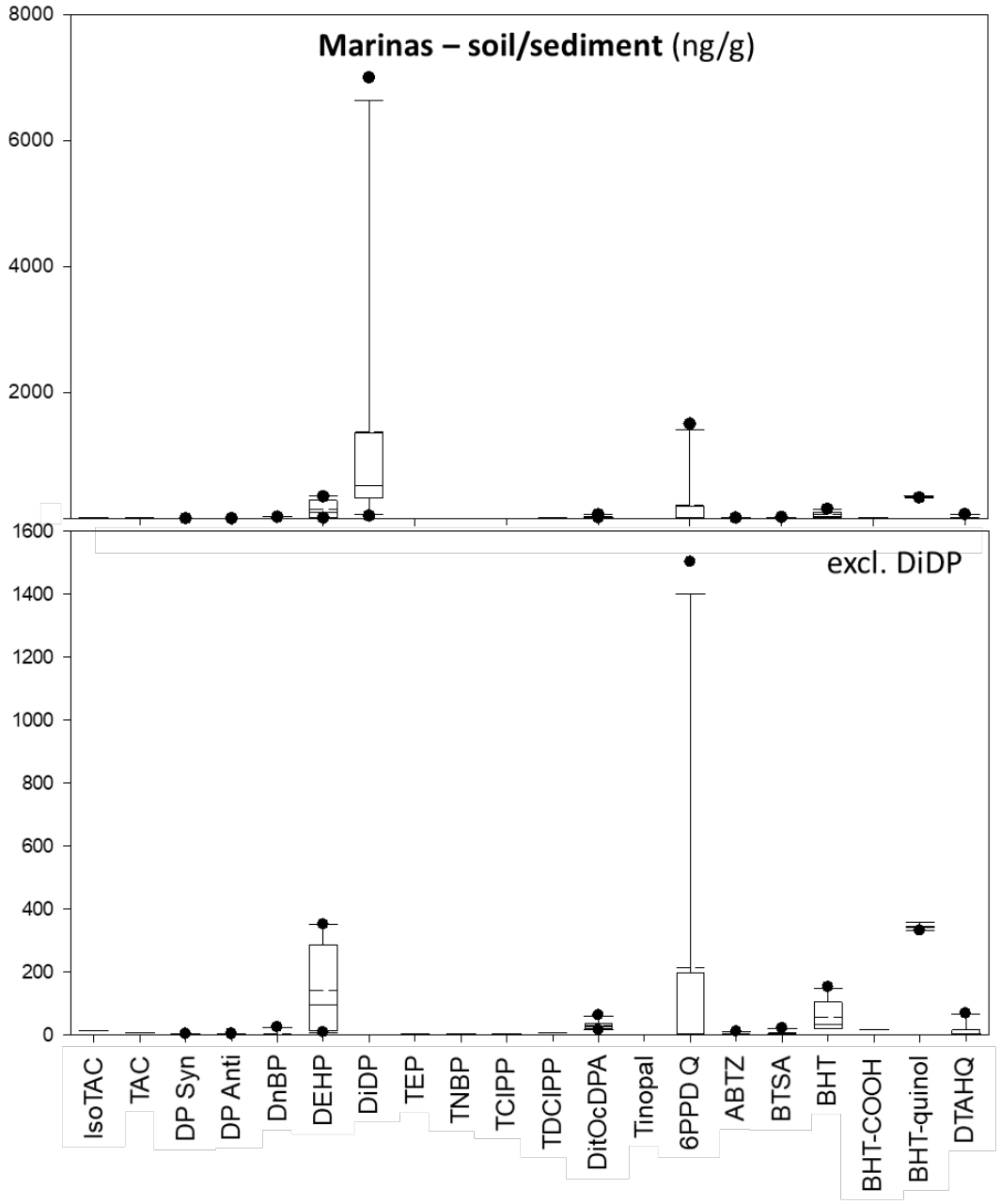


Figure 29: Composition and concentrations of detected compounds in matrices related to the Oslo fjord; WWTP Effluent (ng/L), Alna river water (ng/L) and Marinas – Soil/Sediment (ng/g).

4.3 Artificial turf as a hotspot for compounds of emerging concern

Artificial turfs are made of an artificial “grass” with an infill of so-called filler, which often are granules traditionally made of SBR rubber produced from used car tires or SPMD rubber. Both the grass fibres and especially the filling show a significant loss of material during use direct into the environment, which is shown in a recent study (Bø, Bohne et al. 2020). The authors identified three relevant pathways: (1) shovelling of snow during winter preparation of the turfs, (2) run-off to water and surrounding soil, and (3) deposition on clothes and shoes, which to a relevant degree is ending

up in the washing machine and finally the sewage system. In addition, we assume that there must be another relevant pathway, namely air transport of volatile compounds and dust. As shown in the preceding in chapter 3 and visualized in Table 41, Table 42 and Table 43 there are many compounds, which are detected in both particles form the artificial turfs and in the airborne dust samplers placed at these sites. 6PPD-Q, which is a transformation product of the rubber vulcanization additive 6PPD, is detected in high concentrations in rubber granules and in dust samples placed close at artificial turfs with rubber granules. It was not detected in the airborne dust samplers and at 100 times lower concentrations in granules from artificial turfs with olive stone filling as well as the sites with melted rubber flooring. Airborne dust samplers from turfs with rubber granule fillings also had detectable concentrations of BTSA and MBT.

Table 41: Detection frequency of VOC compounds commonly found in samples of artificial turf granules and airborne dust samples at the artificial turfs. Only compounds shown with an average detection frequency higher than 40%.

Sample description	Benzene	Toluene	m+p-Xylene	o-Xylene	α-Pinene	Styrene	β-Pinene	135-TMBz	3-Carene	124-TMBz	Limonene	p-Cymene	123-TMBz	Terpineol	Lilial
Granules	100	100	100	90	100	100	100	90	90	90	90	90	90	40	60
Dust	100	100	100	100	100	100	100	100	100	100	88	100	100	63	50

Table 42: Detection frequency of plasticizer, SDPA, and BTZ compounds commonly found in samples of artificial turf granules and airborne dust samples at the artificial turfs. Only compounds shown with an average detection frequency higher than 30%.

Sample description	DEHP	DiNP	TEHP	tBuDPA	DtBuDPA	DitOcDPA	6PPD Q	BTZ	ABTZ	MTBTZ	TBBS	PBTZ	CBS	HOBT	Altax	BTSA	MBT
	Plasicizer			SDPA				BTZ									
Granules	80	70	70	60	60	60	100	60	70	100	70	70	70	80	80	70	70
Dust	29	14	0	0	0	0	57	0	0	0	0	0	0	0	0	57	100

Table 43: Detection frequency of phenolic compounds commonly found in samples of artificial turf granules and airborne dust samples at the artificial turfs. Only compounds shown with an average detection frequency higher than 30%.

Sample description	BHT	BHT-CHO	BHT-COOH	PTBP	24-DTBP	BHT-quinol	EP	MB-DTBP	Fenozan	26-DTBP
Granules	60	90	70	60	80	70	80	90	70	70
Dust	0	0	0	0	0	0	0	0	0	14

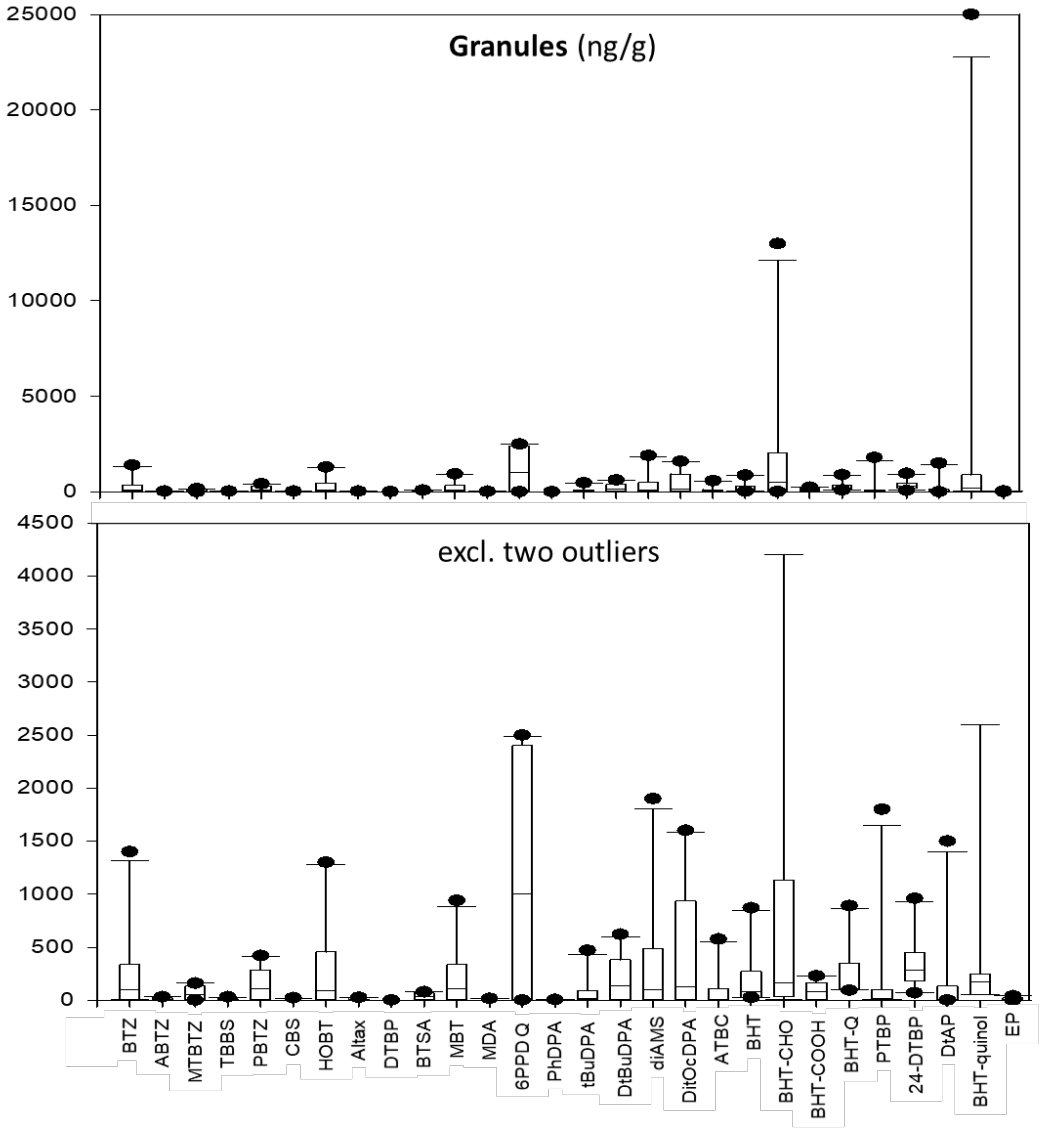


Figure 30: Composition and concentrations of detected compounds in granules (ng/g) from artificial turfs (rubber, olive stones and melted flooring).

4.4 Indoor environmental pollution

As shown in earlier screening studies ((Schlabach, van Bavel et al. 2017, Schlabach, Halse et al. 2019) indoor air, wipes, and dust samples are good sentinels for emerging compounds entering the Norwegian environment. Also, in this study indoor environment including car interior are showing up the highest number of positive detection of selected compounds compared to the other sample types, not exceeding road tunnel wash by concentration but by number of detected compounds (Table 44 to Table 46).

Table 44: Detection frequency of VOC compounds commonly found in samples of indoor air and dust. Only compounds shown with an average detection frequency higher than 40%.

Sample description	Benzene	Toluene	m+p-Xylene	o-Xylene	α-Pinene	Styrene	β-Pinene	135-TMBz	3-Carene	124-TMBz	Limonene	p-Cymene	123-TMBz	Terpineol	Lilial
Nonres. Building	100	100	100	100	100	100	100	100	100	100	100	100	100	70	100
Resid. Building	100	100	100	100	100	100	100	100	100	100	100	100	100	90	40
New building	100	100	100	100	100	100	100	100	100	100	100	100	100	71	57

Table 45: Detection frequency of SVOC, DEC, and plasticizer compounds commonly found in samples of indoor air and dust. Only compounds shown with an average detection frequency higher than 40%.

Sample description	isoTAC	Dpsyn	Dpanti	ATBC	TOTM	DnBP	BBP	DEHP	DCHP	DiNP	DiDP	TCEP	TCIPP	TBOEP	TDCIPP	TPHP	EHDP	TEHP	V6	IDDPP
	SVOC/DEC			**Plasticizer**																
Nonres. Building	78	56	100	89	100	44	89	100	33	100	100	33	22	100	100	100	100	78	89	100
Resid. building	70	20	100	100	100	30	70	100	40	100	100	40	40	80	80	80	80	80	50	100
New building	71	14	57	100	100	29	29	100	86	100	100	29	100	57	71	100	86	29	14	71

Table 46: Detection frequency of BTZ, phenols, and SURF compounds commonly found in samples of indoor air and dust. Only compounds shown with an average detection frequency higher than 40%.

Sample description	Iscotrizinol	HOBT	BTSA	BHT	BHT-CHO	BHT-Q	TTBP	VANOX	D8(HPS)	EP	MP	PP	BuP	DTAHQ	26-DTBP	DTDA-oxide	DDDA-oxide
	BTZ			Phenols												SURF	
Nonres. building	67	67	67	100	44	78	89	89	100	89	67	44	78	56	67	67	67
Resid. building	40	40	40	100	90	60	30	100	70	100	70	100	70	90	100	20	40
New building	57	0	86	71	43	57	43	71	29	71	14	0	14	43	57	71	71

4.5 Biota

Only dechloranes were detected above the limit of detection (LoD) in biota samples. This might seem unexpected, since several of the selected compounds are under assessment for PBT-properties. There are several factors, which should be considered, when discussing the results for the biological samples: The analytical methods used in this study are less specific than the monitoring methods to address all the selected compounds, which cover nearly the whole space of chemical properties (hydrophobic/hydrophilic; volatile /semi volatile/not volatile; persistent/highly degradable etc). To develop methods addressing all compounds within the time frame of this study, it was necessary to limit sample size, the total number of different methods and thus to minimize the specificity of sample preparation and clean-up. For many analytes and sample types it would be feasible to increase sample size and thus reduce LoD, however, with the drawback of extensive and time-consuming refining of methods, increasing total workload, and much higher usage of consumables and solvents for extraction and clean-up. A feasible approach for future screening projects would be to include the substances, which were detected in high concentrations or detection frequencies in the potential emission sources this study (WWTP effluent, indoor air, tunnel wash). In addition, for many of the compounds it is not the parent compound, which is potentially active in biota and accumulating, but the corresponding degradation products or metabolites. To address this problem adequately relevant metabolites (or other transformation products) must be selected, assessed, and included in the analysis. This will need a comprehensive list of relevant metabolites created by searching existing databases or the scientific literature, and the application of *in-silico* prediction tools (Bijlsma, Berntssen et al. 2019). However, it is extremely difficult to cover all metabolites in a standard analytical workflow, as often the analytical standards are not available, and thus falling back to new specialized suspect screening approaches with semi- quantification. (Aalizadeh, Panara et al. 2021).

5 Evaluation of environmental relevance

A relevant tool for evaluation of the relevance of these results is the comparison of the measured concentration with predicted no effect concentrations (PNEC). For prioritisation of compounds ecotoxicological threshold values have been established by experts, which are denoted as Lowest PNECs. A PNEC is obtained through the application of an assessment factor to ecotoxicological endpoints (EC50 or NOECs) using organisms with different sensitivities for different types of chemicals. The assessment factor depends on duration of the test (acute or chronic), the number of trophic concentrations tested and the general uncertainties in predicting ecosystem effects from laboratory data. When no experimental derived PNECs are available, QSAR based prediction models are applied (Aalizadeh, von der Ohe et al. 2017). These values are mostly calculated for the freshwater environment and then transferred to corresponding PNEC value for sediment, marine water, and biota matrices (Dulio, Koschorreck et al. 2020). It is obvious that modelling PNECs includes many simplifications and uncertainties. In addition, most of these lowest PNEC data are not fully reviewed and verified by experts. The following comparison tables should consequently only be used for prioritization and cannot replace more detailed risk assessment.

5.1 Comparison results with NORMAN database PNEC values

Table 47 to Table 49 list the lowest PNEC registered in the NORMAN Database System for freshwater environment, sediment, and biota (NORMAN 2021) together with the corresponding concentrations measured in samples from Alna river surface water, WWTP effluent, road tunnel washing water, sediment and soil from leisure boat marinas, fish liver, herring gull egg, and blue mussels. Only compounds with PNECs close to or below the measured maximum environmental concentration (MEC) are shown and marked yellow or red. These compounds are of environmental concern based on the available PNEC values and further studies on occurrence of these substances is recommended. In some cases, the achieved limit of detection (LoD) for a substance was lower than the predicted PNECs. These cases are marked blue. Even if these compounds are not identified as of environmental concern, the opposite (no risk) is not supported by the analysis performed. Also, these substances should be further investigated to access the risk for the environment.

Table 47: Lowest PNEC (NORMAN 2021) for freshwater environment are compared to maximum concentrations measured in samples from Alna river surface water, WWTP effluent, and road tunnel wash water. Only PNECs close to or below the measured maximum values are shown (for colour code see bottom of the table). Compounds shown here are of some environmental concern and should be prioritized for further in-depth studies.

Group	Acronym	CAS No.	Lowest PNEC	Alna river Surface water	WWTP Effluent	Road tunnel Wash water
			µg/L			
VOC	Benzene	71-43-2	10,00	0,75		19
	Toluene	108-88-3	17,30	120		100
	m+p-Xylene	108-38-3	10,00	2,4		33
	o-Xylene	95-47-6	10,00	1,2		23
	α-Pinene	7785-70-8	0,29	0,19		300
	Styrene	100-42-5	0,01	<0,02		57
	β-Pinene	127-91-3	0,48	0,09		49
	M3T	17928-28-8	1,01	0,37		<0,04
	135-TMBz	108-67-8	4,61	0,45		2,8
	3-Carene	13466-78-9	1,82	0,12		210
	124-TMBz	95-63-6	4,76	0,39		6,7
	p-Cymene	99-87-6	4,40	0,08		16
	123-TMBz	526-73-8	7,38	0,24		2,3
	Lilial	80-54-6	0,44	0,13		9,6
	DCM	75-09-2	20,00	14*)		
	TCM	67-66-3	2,50	40*)		
	BDCM	75-27-4	0,05	3,0*)		
SVOC	isoTAC	1025-15-6	6,94	1,3	1,9	2,4
	TAC	101-37-1	3,57	1,1	1,0	0,23
Plasticizer	DiBP	84-69-5	1,11	<0,04	0,25	0,12
	DnBP	84-74-2	2,30	0,25	2,0	0,25
	BMEP	117-82-8	24,93	<0,02	0,33	8,9
	DEHP	117-81-7	1,30	0,30	0,98	0,38
	DiDP	26761-40-0	0,01	23	360	100
	TCIPP	13674-84-5	120,00	3,8	76	1,1
	TBOEP	78-51-3	24,00	0,86	5,4	<0,02
	TDCIPP	13674-87-8	1,10	0,15	6,2	<0,02
	TPHP	115-86-6	0,74	0,30	1,2	<0,13
	TEHP	78-42-2	0,04	<0,02	<0,02	0,09
	IDDPP	29761-21-5	0,01	<0,012	0,19	<0,012
SDPA	diAMS	10081-67-1	0,00	<0,01	<0,01	0,25
	DitOcDPA	15721-78-5	0,01	<0,01	<0,01	7,2
	Iodocarb	55406-53-6	0,17	<0,01	<0,01	0,63
	VSU	23949-66-8	0,26	<0,01	<0,01	0,22
	6PPD Q	missing	missing	0,23	0,16	18

BTZ	MTBTZ	615-22-5	1,14	<0,01	<0,01	0,70
	PBTZ	883-93-2	0,14	<0,01	<0,01	0,52
	UV-350	36437-37-3	0,01	0,01	<0,01	<0,01
	BTSA	941-57-1	9,97	0,38	0,94	12
Phenols	BHT	128-37-0	0,38	0,28	0,43	0,23
	BHT-CHO	1620-98-0	0,57	<0,12	<0,12	1,2
	BHT-COOH	1421-49-4	1,13	0,10	0,39	0,93
	BHT-Q	719-22-2	0,86	<0,71	<0,71	0,95
	BHT-quinol	10396-80-2	2,51	0,86	0,96	<1,4
	MB-DTBP	118-82-1	0,02	0,17	<0,0052	1,1
	DTAHQ	79-74-3	0,71	<0,026	0,44	0,27
	26-DTBP	128-39-2	0,36	<0,98	<0,98	0,47
Surf	DHDA	112-69-6	0,03	<0,5	<0,5	<0,5
	DTDA	112-75-4	0,06	<0,1	<0,1	<0,1
	DDOA	21542-96-1	0,01	<1	<1	<1
	DODA	124-28-7	0,01	<1	<1	<1
	At least one sample above PNEC (PNEC < MEC)					
	At least one sample close to PNEC (PNEC/5 < MEC < PNEC)					
	Poor limit of detection compared to PNEC (PNEC < LoD)					

*): Only few semi-quantitative results.

Table 48: Lowest PNEC (NORMAN 2021) for marine sediments are compared to maximum concentrations measured in samples of soil and sediments from leisure boat marinas. Only PNECs close to or below the measured maximum values are shown (for colour code see bottom of the table). Compounds shown here are of some environmental concern and should be prioritized for further in-depth studies.

Group	Acronym	CAS No.	Lowest PNEC	Sediment
			ng/g dw	
Plasticizer	ATBC	77-90-7	1,80	8
	TOTM	3319-31-1	0,83	9
	DnBP	84-74-2	9,00	23
	BBP	85-68-7	6,30	3
	DEHP	117-81-7	0,18	95
	DCHP	84-61-7	6,18	37
	EHDP	1241-94-7	0,22	45
SDPA	diAMS	10081-67-1	0,69	47
	DitOcDPA	15721-78-5	1,59	61
BTZ	HOBT	934-34-9	32,32	53
	BTSA	941-57-1	3,26	20
	MBT	149-30-4	0,79	8
Phenols	BHT	128-37-0	8,53	150
	BHT-CHO	1620-98-0	7,29	390
	BHT-Q	719-22-2	0,85	1400
	DCP	97-23-4	7,34	18
	TTBP	732-26-3	5,60	6
	VANOX	17540-75-9	4,05	10
	PTBP	98-54-4	56,32	140
	DtAP	120-95-6	22,51	16
	MP	99-76-3	2,19	7
	MB-DTBP	118-82-1	7,56	200
	Fenozan	20170-32-5	15,32	140
	DTAHQ	79-74-3	64,54	67
	26-DTBP	128-39-2	5,67	3
Surf	DDDA	112-18-5	1,50	1400
	At least one sample above PNEC (PNEC < MEC)			
	At least one sample close to PNEC (PNEC/5 < MEC < PNEC)			
	Poor limit of detection compared to PNEC (PNEC < LoD)			

Table 49: Lowest PNEC (NORMAN 2021) for marine biota are compared to maximum concentrations measured in samples of fish liver (cod and whitening), herring gull egg, and blue mussels. Only PNECs close to or below the measured maximum values are shown (for colour code see bottom of the table). Compounds shown here are of some environmental concern and should be prioritized for further in-depth studies.

Group	Acronym	CAS No.	Lowest PNEC	Fish liver	Gull egg	Blue mussel
			ng/g ww			
SVOC	TIPBP	29225-91-0	0,52			<1
	isoTAC	1025-15-6	1,35			<2,5
	TAC	101-37-1	6,93			<10
	CEA	115-27-5	0,13			<1
Dec *)	Dec602	13560-92-4	0,0000015	0,62	0,08	
	Dec603	31107-44-5	0,0000035	<0,1	0,04	
	DPsyn	135821-03-3	0,0000059	<0,9	1,00	
	DPanti	135821-74-8	0,0000059	1,20	3,30	
SDPA	diAMS	10081-67-1	0,52	<0,5	<0,5	
	Iodocarb	55406-53-6	0,16	<1	<1	
	VSU	23949-66-8	0,24	<1	<1	
BTZ	BTZ	95-16-9	22,76	<20	<20	
	MBTZ	120-75-2	2,90	<20	<20	
	TBBS	95-31-8	0,50	<1	<1	
	PBTZ	883-93-2	2,62	<1	<1	
	CBS	95-33-0	0,96	<1	<1	
	MTBS	95154-01-1	1,60	<1	<1	
	UV-350	36437-37-3	0,41	<1	<1	
	Altax	120-78-5	0,02	<1	<1	
	DTPB	135-57-9	0,04	<1	<1	
	MBT	149-30-4	0,60	<1	<1	
Surf	DDDA	112-18-5	8,04			<50
	DHDA	112-69-6	1,24			<250
	DTDA	112-75-4	4,17			<50
	DDOA	21542-96-1	0,06			<500
	DDA-oxide	2605-79-0	17,57			<50
	DOA	7378-99-6	14,47			<50
	DODA	124-28-7	0,45			<500
	At least one sample above PNEC (PNEC < MEC)					
	At least one sample close to PNEC (PNEC/5 < MEC < PNEC)					
	Poor limit of detection compared to PNEC (PNEC < LoD)					

*): The PNEC values of dechloranes listed by NORMAN seems to be very low and might be outside of the applicability range of the applied QSAR method (Aalizadeh, von der Ohe et al. 2017). A corresponding PNEC for sediments given in a recent Canadian screening study is with 0,0129 mg/kg dw for DP several orders of magnitude higher (Canada 2019).

6 Conclusions

The results of this screening project show that road tunnel wash, car wash facilities and artificial turf potential run off water are indicators for emissions of several of the targeted chemicals to the aquatic environment. In addition, indoor air and dust samples from different locations including hot spots and general public location are shown to give a good overview of currently used chemicals. Both the indoor related samples and WWTP-effluent often contain relatively high or high enough concentrations to detect emerging compounds. This suggests that they are good indicators for the implementation and usage of chemicals in our society and can be used as early warning systems for emission of new chemicals to the ambient environment.

In contrast, in biota samples it was more difficult to detect several of the emerging compounds targeted in this project (e.g. polar and less persistent compounds). The reason for this is the dilution of these compounds in the environment in combination with difficulties to reach very low LoDs for biological samples in a screening approach. This hampers the conclusion of environmental occurrence and suggests that biota is a difficult matrix for an initial screening of polar, less persistent and less bioaccumulating compounds.

From a risk perspective a preliminary assessment using PNEC values from the Norman network (NORMAN 2021) showed that several of the substances were close to or exceeding the PNEC values, this is a reason for concern and these substances should be further investigated in a larger number of samples and over a longer period of time.

The emerging VOCs, α-pinene, 3-carene, p-cymene and lilial in road tunnel wash water were found in concentrations exceeding the PNEC level for fresh water. Although this water will not directly be discharged in the environment, this is a marker for substances coming from road run-off into the aquatic environment. In addition, several known VOCs present in road tunnel water at levels above the PNEC for fresh water, toluene, trichloromethane and dichlorobromomethane exceeded the PNEC in the Alna river on some occasions. The same VOCs were also detected in indoor-related samples, with highest concentrations of α-pinene and 3-carene in buildings, and p-cymene and lilial in vehicle wash facilities and cars after being washed. This suggests that run-off from vehicle wash and buildings also can act as sources for surface water. The sources for pinene in buildings are most likely untreated natural wood materials as the highest concentrations were found in buildings with dominance of wood and furniture storage with wood materials.

The semi volatile organic compounds (SVOC) triallyl cyanurate (TAC) and triallyl isocyanurate (isoTAC) were found at high levels in road tunnel wash, WWTP effluent and at similar levels in surface water at several locations from the Alna river. The maximum levels measured were close to the PNEC values reported for freshwater. IsoTAC was also detected in most of the indoor-related samples but mostly at low concentrations. TAC was only detected in two new cars and one new public building. Both TAC and isoTAC were not detected in biota (blue mussels) but the LoDs were above the PNEC value and further monitoring of both compounds in biota is recommended.

Several plasticisers were found in WWTP effluent at levels close to or above the fresh water PNEC including isodecyl diphenyl phosphate (IDDPP) the levels of the well-studied di-iso-decyl phthalate (DiDP) was found at concentrations above the PNEC. Plasticisers were found in a variety of potential sources including WWTP effluents, the indoor environment and transport related samples, and several in a recipient (the Alna river surface water and sediment) at levels above the PNEC values which is a reason for concern.

The secondary diphenyl amines (SDPA), 4-(2-Phenylpropan-2-yl)-N-[4-(2-phenylpropan-2-yl)phenyl]-aniline (diAMS), and N,N-Bis (4-tert-octylphenyl)amine (DitOcDPA) were found in road tunnel wash water and sediment at concentrations above the PNEC. Several SDPAs were also found in sewage sludge, artificial turf and rubber flooring showing potential sources and entry into the aquatic environment. In addition, a degradation product of the antioxidant/antiozonant N-1,3-dimethylbutyl)-N'-phenyl-1,4-benzene diamine 6PPD-quinone was found in several samples including Alna river surface water. This compound is added to car tires and released to the environment through road run-off and was subsequently found at high concentrations in road tunnel wash water and WWTP effluents. This compound has recently attracted attention in the US where a recent study showed acute toxicity effects of 6PPD-Q on the U.S Pacific Northwest Coho Salmon.

Several benzothiazoles (BTZ) were found in especially road tunnel wash water, but also in artificial turfs with rubber granules. The benzothiazoles 2-(methylthio) benzothiazole (MTBTZ), 2-benzothiazolinone (HOBT), 2-benzothiazolesulfonic acid (BTSA) and 2-mercaptobenzothiazole (MBT) were close to or above PNEC values for fresh water or marine sediments.

Several of phenolic antioxidants were found in both surface water and WWTP effluent at maximum concentrations close to or even above the lowest freshwater PNEC. In addition, for four antioxidants the maximum concentration in road tunnel wash water exceeded the PNEC values. More than 10 antioxidants measured in soil/sediments from leisure boat marinas also exceeded the lowest PNEC for marine sediments. Several phenolic antioxidants were also detected at high concentrations in both artificial turf rubber granules and existing residential and public buildings, suggesting these as emission sources.

1,1,1,3,5,5,5-heptamethyl-3- [(trimethylsilyl)oxy] trisiloxane (M3T) was found in nearly all surface water samples from the Alna river. Even if the concentration is still a factor of five lower than the lowest PNEC registered by NORMAN, it is also under PBT assessment by ECHA and might therefore be of environmental concern. M3T was rarely detected in potential source matrices included in this study. Thus, a wider range of samples as well as other matrices (e.g. domestic wastewater) should analyzed to better characterize the sources and environmental risk of this compound.

Dechlorane 602 and 603, dechlorane plus (syn and anti) were the only compounds found in biological samples exceeding PNEC for marine biota (Fish liver and Herring gull egg). For several other analyses of biota including SVOCs, SDPA, BTZ and surfactants the analytical LoD was above or close to the calculated PNEC values. For several of these compounds, which were found in several potential sources to the (aquatic) environment effects cannot be excluded. The same is true several surfactants which were not found in blue mussel at LoDs below the PNEC value. The surfactant N,N-dimethyldodecan-1-amine (DDDA) was, however, found at concentrations above the PNEC value in leisure boat marinas. In addition, many parent compounds will degrade or metabolise in biota and the parent compound will not be found in biological samples. Here focus on such processes of substances detected at relatively high concentration in potential sources should be further investigated in a similar way as was done for 6PPD and the corresponding quinone was analysed.

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