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Integrated assessment of manufacturing facilities' and clothing's chemical-toxicological impact

Final report

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ABBREVIATIONS

AGTS Analyte Global Toxicity Score
FGTS Facility Global Toxicity Score
GHS Globally Harmonized System of classification and labelling of chemicals
IW Incoming Water
MCA Multi-Criteria Analysis
SGTS Sample Global Toxicity Score
PAHs Polycyclic Aromatic Hydrocarbons
PFOA Poly- and per-fluorinated chemicals
SCCPs Short-Chain Chlorinated Paraffins
UWW Untreated WasteWater
TWW Treated WasteWater
UNECE United Nations Economic Commission for Europe
VOCs Volatile Organic Hydrocarbons

INTRODUCTION

Each chemical compound is characterised by its own type and level of toxicity, therefore making a comparison of chemicals, in order of dangerousness, could be a difficult task. The difficulty lies not only in having to compare very different types of toxicity but also because the relative importance of the types of hazard may change depending on the sample to be assessed.

This work represents the continuation of the collaboration in research carried out between Benetton Group Srl. and the Department of Environmental Science Informatics and Statistics (DAIS) of Ca' Foscari University of Venice[1]. In that previous work a ranking of chemicals based on an adaptation of the multi-criteria method (MCA) was set up. MCA is a technique that permits to evaluate a phenomenon by simultaneously using different criteria, in decision-making environments; the application of MCA allowed us to obtain a single value of toxicity for every compound (AGTS: Analyte Global Toxicity Score), which includes different types of toxicity, thus semplifing the comparison of chemicals, based on a global concept of hazard.

This new work exploits the versatle nature of the MCA method and aims at completing and integreting the assessment previously conducted. It was developed in three phases:

A. The toxicity data collection was completed and updated, adding all the hazards included in the "Globally Harmonized System of classification and labelling of chemicals" (GHS) by the United Nations Economic Commission for Europe (UNECE), to the five type of toxicity chosen within the previous work;
B. A first toxicity ranking of analytes was built for wastewater, applying the same approach used in the previous work. The obtained toxicity scores were used to calculate an additional score (FGTS: Facility Global Toxicity Score), representing the global chemical-toxicological impact of each facility;
C. The approach previously used was re-adapted and applied to pollutants' concentration data in clothing. A new ranking of analytes - specific for these samples - was built and a toxicity score for every textile sample (SGTS: Sample Global Toxicity Score) was calculated.

[1] "Environmental impacts research and smart monitoring strategy development focused on the DETOX Programme", by E. Gregoris, M. Roman, A. Gambaro and C. Barbante, DAIS, Ca' Foscari University of Venice. Technical report, 2016.

1. COLLECTION AND ELABORATION OF TOXICOLOGICAL DATA

1.1. Summary of the method

The MCA method previously optimised for creating a new ranking of compounds, based on a global concept of toxicity, could be summarised as follows. MCA enables people to make decisions involving many kind of corcerns, selecting the best among a number of scenarios. The different scenarios (or alternatives) are evaluated using selected criteria. For this specific purpose, the alternatives are represented by the analysed chemicals and the criteria are the types of hazards. In details, the method consisted in various phases:

A. Selection of criteria for the evaluation. The hazards were selected from those included in the "Globally Harmonized System of classification and labelling of chemicals" (GHS) by the United Nations Economic Commission for Europe (UNECE) (Paragraph 1.3);
B. Estimation of the performance of each alternative respect to each criterion. The performance is represented by the level of toxicity of every compounds, referred to a specific type of hazard (Paragraph 1.4).
C. Estimation of the relative weights of criteria. This aspect is strictly related to the characteristics of the evaluated sample (Paragraph 1.4).
D. Comparison of alternatives. The calculation of AGTS permits to obtain a ranking of analytes, useful for the immediate comparison of compounds, in terms of dangerousness (Paragraph 1.4).

1.2. Analysed chemicals

The evaluation conducted in this work includes two types of sample (wastewater and clothing). Overall 467 different chemical compounds or groups of compounds were analysed - called "analytes": 195 analytes for wastewater and 435 analytes for clothing. As in the previous work, each analyte was assigned a Axxyy code, where xx represents the class and yy the arbitrary order of the analyte into the class. Given that concentration data are produced from different laboratories using different methods, sometimes analytes could represent groups of compounds, including other analytes (as an example, A0105 "Alkylphenols ethoxylates" includes A0102 "Octylphenolethoxylates" and A0104 "Nonylphenolethoxylates"). In these cases all analytes are nominally considered different entities and each analyte was assigned its own toxicological score. Further check in the next processing phase were carried out to ensure that no overlapping analytes are analyzed in the same sample, in order to not overestimate the chemical-toxicicological impact.

Some compounds could be present in different forms in the environment: for every analyte, all available toxicity data regarding the associable compounds was gathered and used for the assessment. For this reason the number of investigated compounds may be higher than the number of analytes (Table 1.1). On the other hand, some analytes have no available toxicological data, thus explaining the classes for which information was gathered for a number of compounds lower than that of the analytes. This latter case may occur also because analytes could be single compounds or classes of compounds, thus the same toxicity information could be used for assessing several analytes. Overall toxicological data of 541 chemical compounds were collected. Table 1.2 lists names and codes of analytes, indicating the type of sample where analytes were measured.

Table 1.1. Classes of analytes, with the correspondent analytes and investigated compounds.

Class	Number analytes	Number of investigated chemicals
01. Alkylphenols	5	8
02. Phthalates	30	22
03. Brominated and Chlorinated Flame Retardants	39	58
04. Dyes	74	73
05. Organotin Compounds	17	18
06. Poly- and per-fluorinated chemicals (PFAS)	37	33
07. Chlorobenzenes and chlorotoluenes	30	28
08. Solvents	28	27
09. Phenols	27	20
10. Short-Chain Chlorinated Paraffins (SCCP)	2	2
11. Metals and metalloids	20	104
12. Cyanide	1	1
13. Pesticides	64	65
14. Biocidics	5	3
15. Organic phosphor acetic acid esters	9	8
16. VOCs - Volatile Organic Compounds	49	45
17. PAHs - Polycyclic aromatic hydrocarbons	24	21
18. Diisocyanates	6	5

Table 1.2. Analytes, CAS and internal code for classification (A). WW: wastewater; C: clothing

A	CAS	Name	WW	C
C01 – Alkylphenols				
A0101	1806-26-4,140-66-9	Octylphenols (OPs)	X	X
A0102	Various	Octylphenolethoxylates (OPEOs)	X	X
A0103	54852-15-3,104-40-5,1173019-62-9	Nonylphenols (NPs)	X	X
A0104	Various	Nonylphenolethoxylates (NPEOs)	X	X
A0105	Various	Alkylphenols ethoxylates		X
C02 – Phthalates				
A0201	85-68-7	Benzyl-butyl-phthalate (BBP)	X	X
A0202	84-74-2	Di-butyl-phthalate (DBP)	X	X
A0203	117-81-7	Di-(2-ethyl-hexyl)-phthalate (DEHP)	X	X
A0204	117-84-0	Di-n-octyl-phthalate (DNOP)	X	X
A0205	68515-48-0	Di-iso-nonyl-phthalate (DINP)	X	X
A0206	26761-40-0	Di-iso-decyl-phthalate (DIDP)	X	X
A0207	131-11-3	Di-methyl-phthalate (DMP)	X	X
A0208	84-66-2	Di-ethyl-phthalate (DEP)	X	X
A0209	131-16-8	Di-n-propyl-phthalate (DPP)	X	X
A0210	84-69-5	Di-iso-butyl-phthalate (DIBP)	X	X
A0211	84-61-7	Di-cyclo-hexyl-phthalate (DCHP)	X	X
A0212	84-75-3	Di-n-hexyl-phthalate (DNHP)	X	X
A0213	84-76-4	Di-nonyl-phthalate (DNP)	X	X
A0214	27554-26-3	Di-iso-octyl-phthalate (DIOP)	X	X
A0215	117-82-8	Bis-(2-methoxy-ethyl)-phthalate (DMEP)	X	X
A0216	605-50-5	Di-iso-pentyl-phthalate (DIPP)	X	X
A0217	71888-89-6	Di-iso-heptyl-phthalate (DIHP)	X	X
A0218	84777-06-0	1,2-Benzene-di-carboxylic acid di-pentyl-esters, branched and linear (DnPP)	X	X
A0219	776297-69-9	N-iso-pentyl-iso-pentyl-phthalate (nPIP)	X	X
A0220	3648-20-2	Di-heptyl-phthalate (DHP)	X	X
A0221	Various	Di-(2-ethyl-hexyl)-phthalate (DEHP) + Di-butyl-phthalate (DBP) + Benzyl-butyl-phthalate (BBP)		X
A0222	Various	Di-iso-nonyl-phthalate (DINP) + Di-iso-decyl-phthalate (DIDP) + Di-n-octyl-phthalate (DNOP)		X
A0223	131-18-0	Di-n-pentylphthalate (DnPP/DPP)		X
A0224	259139-51-0	Di-iso-hexylphthalate (DIHxP)		X
A0225	71888-89-6	1,2-Benzenedicarboxylic acid, di-C6-8-branched alkyl esters, C7-rich (DIHP)		X
A0226	68515-42-4	1,2-Benzenedicarboxylic acid, di-C7-11-branched and linear esters (DHNUP)		X
A0227	68515-51-5	Di-C6-10 Alkyl phthlates		X
A0228	Various	Di-(2-ethyl-hexyl)-phthalate (DEHP) + Di-butyl-phthalate (DBP) + Benzyl-butyl-phthalate (BBP) + Di-iso-butyl-phthalate (DIBP)		X
A0229	88-99-3	1,2-Benzene-di-carboxylic acid / Phthalic acid		X
A0230	Various	Phthalates		
C03 - Brominated and Chlorinated Flame Retardants				
A0301	Various	Polybromodiphenyls (PBBs)	X	X
A0302	126-72-7	Tri-(2,3-di-bromo-propyl)-phosphate (TRIS)	X	X
A0303	Various	Polybromodiphenyl ethers (PBDEs)	X	
A0304	79-94-7	Tetra-bromo-bisphenol-A (TBBPA)	X	X
A0305	5412-25-9	Bis-(2,3-di-bromo-propyl)-phosphate	X	
A0306	3194-55-6	Hexa-bromo-cyclo-dodecan (HBCDD)	X	X
A0307	3296-90-0	2,2-Bis(bromomethyl)-1,3-propanediol (BBMP)	X	X
A0308	115-96-8	Tris-(2-chloro-ethyl)-phosphate (TCEP)	X	
A0309	13674-87-8	Tris-(1,3-di-chloro-iso-propyl)-phosphate (TDCPP)	X	X
A0310	Various	Bromo-diphenyl	X	X
A0311	Various	Di-bromo-diphenyl	X	
A0312	Various	Tri-bromo-diphenyl	X	
A0313	Various	Tetra-bromo-diphenyl	X	
A0314	Various	Penta-bromo-diphenyl	X	
A0315	Various	Hexa-bromo-diphenyl	X	
A0316	Various	Hepta-bromo-diphenyl	X	

Table 1.2. (continued)

A	CAS	Name	WW	C
A0317	Various	Octa-bromo-diphenyl	X	
A0318	Various	Nona-bromo-diphenyl	X	
A0319	13654-09-6	Deca-bromo-diphenyl	X	
A0320	Various	Bromo-diphenyl-ether	X	
A0321	Various	Di-bromo-diphenyl-ether	X	
A0322	Various	Tri-bromo-diphenyl-ether	X	
A0323	Various	Tetra-bromo-diphenyl-ether (TetraBDE)	X	X
A0324	Various	Penta-bromo-diphenyl-ether (PentaBDE)	X	X
A0325	Various	Hexa-bromo-diphenyl-ether	X	X
A0326	Various	Hepta-bromo-diphenyl-ether	X	X
A0327	Various	Octa-bromo-diphenyl-ether	X	X
A0328	Various	Nona-bromo-diphenyl-ether	X	
A0329	1163-19-5	Deca-bromo-diphenyl-ether	X	X
A0330	21850-44-2	Tetra-bromo-bisphenol A bis-(di-bromo-propyl-ether) (TBBPA-BDPE)	X	
A0331	13674-84-5	Tris-(2-chloroisopropyl)-phosphate (TCPP)	X	
A0332	Various	Tris-(aziridinyl)-phosphinoxide (TEPA)	X	X
A0333	-	BDBPT		X
A0334	111-96-6	Bis(2-methoxyethyl)-ether		X
A0335	1303-86-2	Diboron trioxide (BTO)		X
A0336	5412-25-9	Bis (2,3-dibromopropyl) phosphate (BIS/BIS-BP)		X
A0337	10043-35-3	Boric acid (HB)		X
A0338	12267-73-1	Tetraboron disodium heptaoxide, hydrate (TBHO)		X
A0339	78-30-8	Tri-o-cresyl phosphate		X
C04 - Azodyes				
A0401	92-67-1	4-Aminodiphenyl	X	X
A0402	92-87-5	Benzidine	X	X
A0403	95-69-2	4-Chloro-o-toluidine	X	X
A0404	91-59-8	2-Naphthylamine	X	X
A0405	97-56-3	o-Aminoazotoluene	X	X
A0406	99-55-8	2-Amino-4-nitrotoluene	X	X
A0407	106-47-8	p-Chloroaniline	X	X
A0408	615-05-4	2,4-Diaminoanisole	X	X
A0409	101-77-9	4,4'-Diaminodiphenylmethane	X	X
A0410	91-94-1	3,3'-Dichlorobenzidine	X	X
A0411	119-90-4	3,3'-Dimethoxybenzidine	X	X
A0412	119-93-7	3,3'-Dimethylbenzidine	X	X
A0413	838-88-0	3,3'-Dimethyl-4,4'-diaminodiphenylmethane	X	X
A0414	120-71-8	p-Cresidine	X	X
A0415	101-14-4	4,4'-Methylenebis(2-chloroaniline)	X	X
A0416	101-80-4	4,4'-Oxydianiline	X	X
A0417	139-65-1	4,4'-Thiodianiline	X	X
A0418	95-53-4	o-Toluidine	X	X
A0419	95-80-7	2,4-Toluenediamine	X	X
A0420	137-17-7	2,4,5-Trimethylaniline	X	X
A0421	90-04-0	o-Anisidine	X	X
A0422	60-09-3	4-Aminoazobenzene	X	X
A0423	95-68-1	2,4-Xylidine	X	X
A0424	87-62-7	2,6-Xylidine	X	X
A0425	62-53-3	Aniline	X	X
A0426	106-50-3	1,4-Phenylenediamine	X	X
A0427	95-51-2	2-Chloroaniline	X	
A0428	99-59-2	5-Nitro-o-anisidine	X	
A0429	108-44-1	m-Toluidine	X	X
A0430	91-66-7	n,n-Diethylaniline	X	
A0431	103-69-5	n-Ethylaniline	X	
A0432	100-61-8	n-Methylaniline	X	
A0433	106-49-0	p-Toluidine	X	X
A0434	2475-45-8	Disperse blue 1		X
A0435	2475-46-9	Disperse blue 3		X
A0436	3179-90-6	Disperse blue 7		X
A0437	3860-63-7	Disperse blue 26		X
A0438	12222-75-2	Disperse blue 35		X
A0439	12222-97-8	Disperse blue 102		X
A0440	12223-01-7	Disperse blue 106		X
A0441	61951-51-7	Disperse blue 124		X
A0442	23355-64-8	Disperse brown 1		X
A0443	2581-69-3	Disperse orange 1		X
A0444	730-40-5	Disperse orange 3		X
A0445	13301-61-6	Disperse orange 37 / 76 / 59		X

Table 1.2. (continued)

A	CAS	Name	WW	C
A0446	85136-74-9	Disperse orange 149		X
A0447	2872-52-8	Disperse red 1		X
A0448	2872-48-2	Disperse red 11		X
A0449	3179-89-3	Disperse red 17		X
A0450	119-15-3	Disperse yellow 1		X
A0451	2832-40-8	Disperse yellow 3		X
A0452	6373-73-5	Disperse yellow 9		X
A0453	6250-23-3	Disperse yellow 23		X
A0454	12236-29-2	Disperse yellow 39		X
A0455	6858-49-7	Disperse yellow 49		X
A0456	16071-86-6	Direct brown 95		X
A0457	573-58-0	Direct red 28		X
A0458	2602-46-2	Direct blue 6		X
A0459	3761-53-3	Acid red 26		X
A0460	5413-75-2	Acid red 73		X
A0461	569-61-9	Basic red 9		X
A0462	632-99-5	Basic violet 14		X
A0463	1937-37-7	Direct black 38		X
A0464	60-09-3	Solvent yellow 1		X
A0465	60-11-7	Solvent yellow 2		X
A0466	97-56-3	Solvent yellow 3		X
A0467	82-28-0	Disperse orange 11		X
A0468	8004-87-3	Basic violet 1		X
A0469	548-62-9	Basic violet 3		X
A0470	1694-09-3	Acid violet 49		X
A0471	Various	Aminochlorophenols		X
A0472	Various	Navy blue		X
A0473	2580-56-5	Basic blue 26		X
A0474	569-64-2	Basic green 4		X
C05 - Organotin compounds				
A0501	Various	Monobutyltin (MBT)	X	X
A0502	Various	Dibutyltin (DBT)	X	X
A0503	Various	Dioctyltin (DOT)	X	X
A0504	Various	Tributyltin (TBT)	X	X
A0505	Various	Triphenyltin (TPhT)	X	X
A0506	Various	Tricyclohexyltin (TCyHT)	X	X
A0507	Various	Trioctyltin (TriOT)	X	X
A0508	Various	Tripropyltin (TPT)	X	X
A0509	Various	Monooctyltin (MOT)	X	X
A0510	1461-25-2	Tetrabutyltin (TeBT)	X	X
A0511	597-64-8	Tetraethyltin (TeEtT)		X
A0512	Various	Diphenyltin (DPhT)		X
A0513	Various	Dimethyltin (DMT)		X
A0514	Various	Trimethyltin (TMT)		X
A0515	Various	Methyltin (MT)		X
A0516	Various	Monoethyltin (MET)		X
A0517	Various	Monopropyltin (MPT)		X
C06 - Poly- and per-fluorinated chemicals (PFAS)				
A0601	335-67-1	Perfluoro-n-octanoic acid (PFOA)	X	X
A0602	Various	Perfluorooctane sulphonates (PFOS)	X	X
A0603	307-24-4	Perfluoro-n-hexanoic acid (PFHxA)	X	X
A0604	Various	Perfluorohexane sulphonates (PFHxS)	X	
A0605	375-22-4	Perfluorobutanoic acid (PFBA)	X	X
A0606	375-73-5	Perfluoro-butane-sulfonic acid	X	X
A0607	754-91-6	Perfluorooctanesulfonamide (PFOSA)	X	X
A0608	31506-32-8	N-Methyl-perfluorooctanesulfonamide (N-Me-FOSA)	X	X
A0609	4151-50-2	N-Ethyl-perfluorooctanesulfonamide (N-Et-FOSA)	X	X
A0610	24448-09-7	N-Methyl-perfluorooctanesulfonamidoethanol (N-Me-FOSE)	X	X
A0611	1691-99-2	N-Ethyl-Perfluorooctanesulfonamidoethanol (N-Et-FOSE)	X	X
A0612	2706-90-3	Perfluoropentanoic acid (PFPeA)	X	X
A0613	375-85-9	Perfluoroheptanoic acid (PFHpA)	X	X
A0614	375-95-1	Perfluorononanoic acid (PFNA)	X	X
A0615	335-76-2	Perfluorodecanoic acid (PFDA)	X	X
A0616	2058-94-8	Perfluoroundecanoic acid (PFUnA)	X	X
A0617	307-55-1	Perfluorododecanoic acid (PFDoA)	X	X
A0618	72629-94-8	Perfluorotridecanoic acid (PFTrA)	X	X

Table 1.2. (continued)

A	CAS	Name	WW	C
A0619	376-06-7	Perfluorotetradecanoic acid (PFTeA)	X	X
A0620	355-46-4	Perfluorohexanesulfonic acid (PFHxS)	X	X
A0621	375-92-8	Perfluoroheptanesulfonic acid (PFHpS)	X	X
A0622	355-77-3	Perfluorodecanesulfonic acid (PFDS)	X	X
A0623	27619-97-2	1H,1H,2H,2H-Perfluorooctanesulphonic acid (1H,1H,2H,2H-PFOS)	X	X
A0624	34598-33-9	2H,2H,3H,3H-Perfluoroundecanoic acid (H4PFUnA)	X	X
A0625	172155-07-6	Perfluoro-3-7-dimethyl octane carboxylate	X	
A0626	1546-95-8	7H-Dodecafluoro heptane carboxylate	X	
A0627	1763-23-1	Perfluorooctane sulfonic acid	X	
A0628	2043-47-2	1H,1H,2H,2H-Perfluorohexane-1-ol (4:2 FTOH)		X
A0629	647-42-7	1H,1H,2H,2H-Perfluoro-1-octanol (6:2 FTOH)		X
A0630	678-39-7	1H,1H,2H,2H-Perfluoro-1-decanol (8:2 FTOH)		X
A0631	865-86-1	1H,1H,2H,2H-Perfluorododecan-1-ol (10:2 FTOH)		X
A0632	17527-29-6	1H,1H,2H,2H-Perfluorooctylacrylate (6:2 FTA)		X
A0633	27905-45-9	1H,1H,2H,2H-Perfluorodecylacrylate (8:2 FTA)		X
A0634	17741-60-5	1H,1H,2H,2H-Perfluorododecylacrylate (10:2 FTA)		X
A0635	882489-14-7	2H,2H-Perfluorodecanoate (H2PFDA)		X
A0636	1546-95-8	7H-Dodecafluoroheptanoate (HPFHpA)		X
A0637	172155-07-6	Perfluoro-3,7-dimethyloctanoate (PF-3,7-DMOA)		X
C07 - Chlorobenzenes and chlorotoluenes				
A0701	108-90-7	Monochlorobenzene	X	X
A0702	Various	Dichlorobenzenes	X	X
A0703	Various	Trichlorobenzenes	X	X
A0704	Various	Tetrachlorobenzenes	X	X
A0705	608-93-5	Pentachlorobenzene	X	X
A0706	118-74-1	Hexachlorobenzene	X	X
A0707	95-50-1	1,2-Dichlorobenzene	X	X
A0708	541-73-1	1,3-Dichlorobenzene	X	X
A0709	106-46-7	1,4-Dichlorobenzene	X	X
A0710	87-61-6	1,2,3-Trichlorobenzene	X	X
A0711	120-82-1	1,2,4-Trichlorobenzene	X	X
A0712	108-70-3	1,3,5-Trichlorobenzene	X	X
A0713	634-66-2	1,2,3,4-Tetrachlorobenzene	X	X
A0714	634-90-2	1,2,3,5-Tetrachlorobenzene	X	X
A0715	95-94-3	1,2,4,5-Tetrachlorobenzene	X	X
A0716	Various	1,3-Dichlorobenzene, 1,4-Dichlorobenzenes	X	
A0717	Various	1,2,3,5-Tetrachlorobenzene, 1,2,4,5-Tetrachlorobenzene	X	
A0718	Various	Chlorotoluenes		X
A0719	Various	Dichlorotoluenes		X
A0720	Various	Trichlorotoluenes		X
A0721	Various	Tetrachlorotoluenes		X
A0722	Various	Pentachlorotoluene		X
A0723	95-49-8	2-Chlorotoluene		X
A0724	106-43-4	4-Chlorotoluene		X
A0725	108-41-8	3-Chlorotoluene		X
A0726	32768-54-0	2,3-Dichlorotoluene		X
A0727	95-73-8	2,4-Dichlorotoluene		X
A0728	19398-61-9	2,5-Dichlorotoluene		X
A0729	118-69-4	2,6-Dichlorotoluene		X
A0730	95-75-0	3,4-Dichlorotoluene		X
C08 - Solvents				
A0801	75-09-2	Dichloromethane	X	X
A0802	67-66-3	Trichloromethane / Chloroform	X	X
A0803	56-23-5	Carbon tetrachloride	X	X
A0804	107-06-2	1,2-Dichloroethane	X	X
A0805	71-55-6	1,1,1-Trichloroethane	X	X
A0806	79-00-5	1,1,2-Trichloroethane	X	X
A0807	630-20-6	1,1,1,2-Tetrachloroethane	X	X
A0808	79-34-5	1,1,2,2-Tetrachloroethane	X	X
A0809	76-01-7	Pentachloroethane	X	X
A0810	75-35-4	1,1-Dichloroethylene	X	X

Table 1.2. (continued)

A	CAS	Name	WW	C
A0811	156-59-2	cis-1,2-Dichloroethylene	X	X
A0812	156-60-5	trans-1,2-Dichloroethylene	X	X
A0813	79-01-6	Trichloroethylene	X	X
A0814	127-18-4	Tetrachloroethylene	X	X
A0815	100-44-7	Benzyl chloride		X
A0816	67-72-1	Hexachloroethane		X
A0817	75-34-3	1,1-Dichloroethane		X
A0818	563-58-6	1,1-Dichloropropene		X
A0819	10061-01-5	cis-1,3-Dichloropropene		X
A0820	10061-01-5	trans-1,3-Dichloropropene		X
A0821	78-87-5	1,2-Dichloropropane		X
A0822	96-18-4	1,2,3-Trichloropropane		X
A0823	142-28-9	1,3-Dichloropropane		X
A0824	594-20-7	2,2-Dichloropropane		X
A0825	90-43-7	Orthophenylphenol		X
A0826	68-12-2	Dimethylformamide (DMFa)		X
A0827	872-50-4	1-Methyl-2-pyrrolidone		X
A0828	127-19-5	Dimethylacetamide		X
C09 - Phenols				
A0901	Various	Monochlorophenols (MCP)	X	X
A0902	Various	Dichlorophenol (DCP)	X	X
A0903	Various	Trichlorophenols (TCP)	X	X
A0904	Various	Tetrachlorophenols (TeCP)	X	X
A0905	87-86-5	Pentachlorophenol (PCP)	X	X
A0906	95-57-8	2-Chlorophenol	X	X
A0907	108-43-0	3-Chlorophenol	X	X
A0908	106-48-9	4-Chlorophenol	X	X
A0909	576-24-9	2,3-Dichlorophenol	X	X
A0910	95-77-2	3,4-Dichlorophenol	X	X
A0911	Various	2,4-Dichlorophenol, 2,5-Dichlorophenol, 2,6-Dichlorophenol, 3,5-Dichlorophenol	X	X
A0912	933-78-8	2,3,5-Trichlorophenol	X	X
A0913	95-95-4	2,4,5-Trichlorophenol	X	X
A0914	88-06-2	2,4,6-Trichlorophenol	X	X
A0915	Various	3,4,5-Trichlorophenol, 2,3,4-Trichlorophenol	X	
A0916	4901-51-3	2,3,4,5-Tetrachlorophenol	X	X
A0917	58-90-2	2,3,4,6-Tetrachlorophenol	X	X
A0918	935-95-5	2,3,5,6-Tetrachlorophenol	X	X
A0919	15950-66-0	2,3,4-Trichlorophenol	X	X
A0920	609-19-8	3,4,5-Trichlorophenol	X	X
A0921	120-83-2	2,4-Dichlorophenol	X	X
A0922	583-78-8	2,5-Dichlorophenol	X	X
A0923	87-65-0	2,6-Dichlorophenol	X	X
A0924	591-35-5	3,5-Dichlorophenol	X	X
A0925	933-75-5	2,3,6-Trichlorophenol		X
A0926	119-47-1	2,2'-Methylenebis(6-tert-butyl-p-cresol)		X
A0927	Various	Chlorinated Phenols		X
C10 - Short-Chain Chlorinated Paraffins (SCCP)				
A1001	85535-84-8	Short-chain chlorinated paraffins (C10-C13)	X	X
A1002	85535-85-9	Short-chain chlorinated paraffins (C14-C17)		X
C11 - Metals and metalloids				
A1101	Various	Chromium (Cr)	X	X
A1102	Various	Hexavalent chromium (Cr VI)	X	X
A1103	Various	Manganese (Mn)	X	X
A1104	Various	Cobalt (Co)	X	X
A1105	Various	Nickel (Ni)	X	X
A1106	Various	Copper (Cu)	X	X
A1107	Various	Zinc (Zn)	X	X
A1108	Various	Arsenic (As)	X	X
A1109	Various	Cadmium (Cd)	X	X
A1110	Various	Antimony (Sb)	X	X
A1111	Various	Mercury (Hg)	X	X
A1112	Various	Lead (Pb)	X	X
A1113	Various	Tin (Sn)		X
A1114	Various	Aluminium (Al)		X
A1115	Various	Barium (Ba)		X
A1116	Various	Boron (B)		X
A1117	Various	Selenium (Se)		X
A1118	Various	Strontium (Sr)		X
A1119	Various	Heavy metals (Cd, Cr (VI), Pb, Hg)		X
C12 - Cyanide				

Table 1.2. (continued)

A	CAS	Name	WW	C
A1201	74-90-8	Cyanide	X	X
C13 - Pesticides				
A1301	93-76-5	2,4,5-T		X
A1302	57648-21-2	DTTB / Timiperone		X
A1303	1897-45-6	Chlorthalonil		X
A1304	465-73-6	Isodrin		X
A1305	94-75-7	2,4-D		X
A1306	86-50-0	Azinophos-methyl		X
A1307	2642-71-9	Azinophos-ethyl		X
A1308	309-00-2	Aldrin		X
A1309	4824-78-6	Bromophosethyl		X
A1310	2425-06-1	Captafol		X
A1311	63-25-2	Carbaryl		X
A1312	510-15-6	Chlorbenzilate		X
A1313	57-74-9	Chlordane		X
A1314	143-50-0	Chlordecone / Kepone		X
A1315	6164-98-3	Chlordimeform		X
A1316	470-90-6	Chlorfenvinphos		X
A1317	56-72-4	Coumaphos		X
A1318	68359-37-5	Cyfluthrin		X
A1319	91465-08-6	Cyhalothrin		X
A1320	52315-07-8	Cypermethrin		X
A1321	52918-63-5	Deltamethrin		X
A1322	Various	DDD		X
A1323	Various	DDE		X
A1324	Various	DDT		X
A1325	333-41-5	Diazinon		X
A1326	120-36-5	Dichlorprop		X
A1327	1085-98-9	Dichlorfluanid		X
A1328	141-66-2	Dicrotophos		X
A1329	60-57-1	Dieldrin		X
A1330	60-51-5	Dimethoate		X
A1331	Various	Dinoseb and its salts		X
A1332	959-98-8	alpha-Endosulfan		X
A1333	33213-65-9	beta-Endosulfan		X
A1334	72-20-8	Endrin		X

A	CAS	Name	WW	C
A1335	66230-04-4	Fenvalerat / Esfenvalerate		X
A1336	76-44-8	Heptachlor		X
A1337	1024-57-3	Heptachlorepoxid		X
A1338	118-74-1	Hexachlorbenzene		X
A1339	319-84-6	alpha-Hexachlorcyclohexane		X
A1340	319-85-7	beta-Hexachlorcyclohexane		X
A1341	319-86-8	delta-Hexachlorcyclohexane		X
A1342	58-89-9	Lindane / g-HCH		X
A1343	4234-79-1	Kelevan		X
A1344	121-75-5	Malathion		X
A1345	94-74-6	MCPA		X
A1346	94-81-5	MCPB		X
A1347	93-65-2	Mecoprop		X
A1348	10265-92-6	Metamidophos		X
A1349	72-43-5	Methoxychlor		X
A1350	2385-85-5	Mirex		X
A1351	6923-22-4	Monocrotophos		X
A1352	56-38-2	Parathion		X
A1353	298-00-0	Parathion-methyl		X
A1354	1825-21-4	Pentachloroanisol		X
A1355	52645-53-1	Permethrin		X
A1356	7786-34-7	Phosdrin / Mevinphos		X
A1357	31218-83-4	Propethamphos		X
A1358	41198-08-7	Profenophos		X
A1359	13593-03-8	Quinalphos		X
A1360	82-68-8	Quintozene		X
A1361	8001-50-1	Strobane		X
A1362	297-78-9	Telodrin / Isobenzan		X
A1363	731-27-1	Tolyfluanid		X
A1364	1582-09-8	Trifluralin		X
C14 - Biocides				
A1401	3380-34-5	Triclosane		X
A1402	26172-55-4	5-Chloro-2-methyl-4-isothiazoline-3-one		X
A1403	2682-20-4	2-Methyl-4-isothiazolin-3-one		X
A1404	26530-20-1	2-Octyl-4-isothiazoline-3-one		X
A1405	Various	Biocidic finish		X

Table 1.2. (continued)

A	CAS	Name	WW	C
C15 - Organic phosphor acetic acid esters				
A1501	78-30-8	Tri-o-cresyl phosphate		X
A1502	115-96-8	Tri(2-chloroethyl)-phosphate		X
A1503	512-56-1	Trimethylphosphate		X
A1504	78-40-0	Triethylphosphate		X
A1505	126-71-6	Triisobutylphosphate		X
A1506	126-73-8	Tributylphosphate		X
A1507	78-51-3	Tris(2-buthoxyethyl)phosphate		X
A1508	115-86-6	Triphenylphosphate		X
A1509	78-42-2	Tris(2-ethylhexyl)phosphate		X
C16 - VOCs - Volatile Organic Compounds				
A1601	50-00-0	Formaldehyde		X
A1602	106-44-5	p-Cresol		X
A1603	112-49-2	Triethylene glycol dimethyl ether		X
A1604	108-38-3	m-Xylene		X
A1605	106-42-3	p-Xylene		X
A1606	2381-21-7	1-Methylpyrene		X
A1607	78-93-3	2-Butanone		X
A1608	110-80-5	2-Ethoxyethanol		X
A1609	104-76-7	2-Ethyl-1-hexanol		X
A1610	111-15-9	2-Ethoxyethyl acetate		X
A1611	100-52-7	Benzaldehyde		X
A1612	75-65-0	tert-Butanol		X
A1613	108-86-1	Bromobenzene		X
A1614	74-97-5	Bromochloromethane		X
A1615	75-27-4	Bromodichloromethane		X
A1616	75-25-2	Bromoform		X
A1617	108-94-1	Cyclohexanone		X
A1618	124-48-1	Dibromochloromethane		X
A1619	74-95-3	Dibromomethane		X
A1620	100-41-4	Ethylbenzene		X
A1621	87-68-3	Hexachlorobutadiene		X
A1622	78-59-1	Isophorone		X
A1623	98-82-8	Isopropylbenzene		X
A1624	95-47-6	o-Xylene		X
A1625	Various	m-/p-Xylene		X
A1626	Various	Xylene (o-/m-/p-)		X
A1627	104-51-8	n-Butylbenzene		X
A1628	110-54-3	n-Hexane		X
A1629	103-65-1	n-Propylbenzene		X
A1630	108-95-2	Phenol		X
A1631	99-87-6	p-Isopropyltoluene		X
A1632	135-98-8	sec-Butylbenzene		X
A1633	100-42-5	Styrene		X
A1634	98-06-6	tert-Butylbenzene		X
A1635	108-88-3	Toluene		X
A1636	106-93-4	1,2-Dibromoethane		X
A1637	96-12-8	1,2-Dibromo-3-chloropropane		X
A1638	95-63-6	1,2,4-Trimethylbenzene		X
A1639	108-67-8	1,3,5-Trimethylbenzene		X
A1640	617-94-7	2-Phenyl-2-propanole		X
A1641	98-86-2	Acetophenone		X
A1642	71-43-2	Benzene		X
A1643	624-49-7	Dimethylfumarate (DMFu)		X
A1644	109-86-4	2-Methoxyethanol		X
A1645	110-49-6	2-Methoxyethylacetate		X
A1646	70657-70-4	2-Methoxypropylacetate		X
A1647	110-71-4	Ethylene glycol dimethyl ether		X
A1648	108-39-4	m-Cresol		X
A1649	95-48-7	o-Cresol		X
C17 - PAHs - Polycyclic aromatic hydrocarbons				
A1701	91-20-3	Naphthalene		X
A1702	208-96-8	Acenaphthylene		X
A1703	83-32-9	Acenaphthene		X
A1704	86-73-7	Fluorene		X
A1705	85-01-8	Phenanthrene		X
A1706	120-12-7	Anthracene		X
A1707	206-44-0	Fluoranthene		X
A1708	129-00-0	Pyrene		X
A1709	56-55-3	Benzo(a)anthracene		X
A1710	218-01-9	Chrysene		X
A1711	205-99-2	Benzo(b)fluoranthene		X

Table 1.2. (continued)

A	CAS	Name	WW	C
A1712	207-08-9	Benzo(k)fluoranthene		X
A1713	50-32-8	Benzo(a)pyrene		X
A1714	191-24-2	Benzo(g,h,i)perylene		X
A1715	193-39-5	Indeno(1,2,3-cd)pyrene		X
A1716	53-70-3	Dibenzo(a,h)anthracene		X
A1717	192-97-2	Benzo(e)pyrene		X
A1718	205-82-3	Benzo(j)fluoranthene		X
A1719	27208-37-3	Cyclopenta(c,d)pyrene		X
A1720	192-65-4	Dibenzo(a,e)pyrene		X
A1721	191-30-0	Dibenzo(a,l)pyrene		X
A1722	189-55-9	Dibenzo (a, i) pyrene		X
A1723	189-64-0	Dibenzo(a,h)pyrene		X
A1724	Various	Benzo(b)fluoranthene + Benzo(k)fluoranthene		X
C18 - Diisocyanates				
A1801	584-84-9	2,4-Toluene diisocyanate (2,4-TDI)		X
A1802	91-08-7	2,6-Toluene diisocyanate (2,6-TDI)		X
A1803	101-68-8	Diphenylmethane diisocyanate (MDI)		X
A1804	822-06-0	Hexamethylene diisocyanate (HDI)		X
A1805	4098-71-9	Isophorone diisocyanate (IPDI)		X
A1806	2778-42-9	Tetramethylxylene diisocyanate (TMXDI)		X

1.3. Collection of toxicity data

All types of hazard included in the "Globally Harmonized System of classification and labelling of chemicals", introduced by the United Nations Economic Commission for Europe (UNECE), were considered. Within this classification hazards are divided into three classes: physical hazards, health hazards and environmental hazards, as summarised in Table 1.3.

Table 1.3. Classification of hazards within the "Globally Harmonized System of classification and labelling of chemicals".

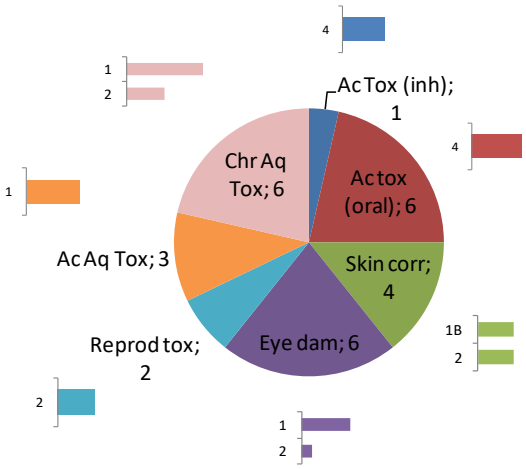
Physical hazard	Health hazard	Environmental hazard
Explosives	Acute toxicity	Hazardous to the acquatic environment (acute or chronic toxicity)
Flammable gases	Skin corrosion/irritation	Hazardous to the ozone layer
Aerosols	Serious eye damage/eye irritation	
Oxidizing gases	Respiratory or skin sensitization	
Gases under pressure	Germ cell mutagenicity	
Flammable liquids	Carcinogenicity	
Flammable solids	Reproductive toxicity	
Self-reactive substances and mixtures	Specific target organ toxicity (single or repeated exposure)	
Pyrophoric liquids	Aspiration hazard	
Pyrophoric solids		
Self-heating substances and mixtures		
Substances and mixtures which, in contact with water, emit flammable gases		
Oxidizing liquids		
Oxidizing solids		
Organic peroxides		
Corrosive to metals		

For most types of hazard toxicological data include also a "category", indicated with a cardinal number (category 1, category 2, etc.), which represents the level of hazard. Usually, more little is the number of the category, more dangerous is the substance. The classification in categories is based on different criteria, depending on the type of toxicity: as an example, the lethal dose is used for the categorisation of the acute toxicity; for hazards like cancerogenicity, reproductive toxicity and germ cell mutagenicity, categories are defined depending on the probability of the occurence of the effect; other hazards (skin corrosion, eye damage, ...) are categorised based on reversibility (or not) of the effect and on the time needed for the reversibility. A summarised explanation of the criteria used in the "Globally Harmonized System of classification and labelling of chemicals" for categorisation of substances is given in the Annex "Toxicity information" (Table A1 and Table A2). The same annex also reports all toxicity data collected (Table A3).

Table 1.4 summaries the toxicological characteristics of classes of analytes. The pie chart represents the types of hazards characterising the class; the number of compounds which show the single type of hazard is reported in the corresponding slice, while the total number of investigated compounds of the class is reported in brackets, near the name of the class. Further information about the specific type of hazard is given using histograms, located close to the corresponding slice. Each hystogram reports the categories which the compounds are classified in. As an example 6 alkylphenols over 8 are characterised by acute toxicity, all these compounds are classified as acute toxicity, category 4; 4 alkylphenols show eye damage, most of them are classified as eye damage, category 1.

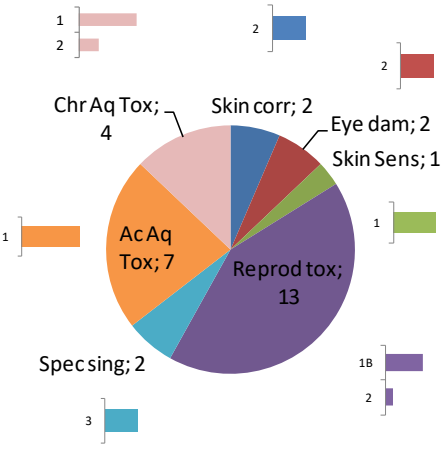
Table 1.4. Summary of the toxicological characteristics of each class of analytes. In brackets the number of the investigated analytes per class.

1. Alkylphenols (8)



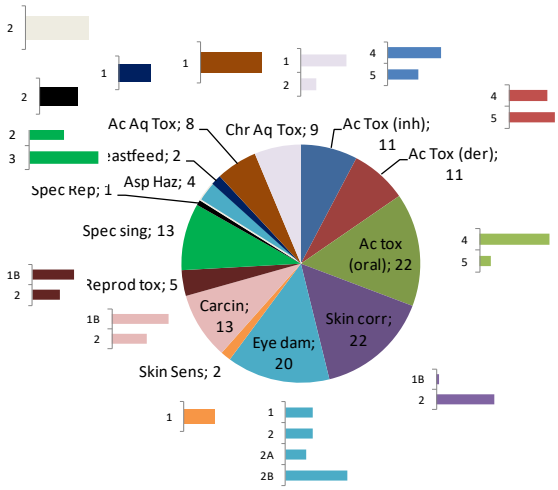
- Some alkylphenols are very toxic to acquatic organisms and may cause long-term adverse effects in the acquatic environment;
- Some alkylphenols are suspected to impair human fertility and cause harm to unborn children.

2. Phthalates (22)



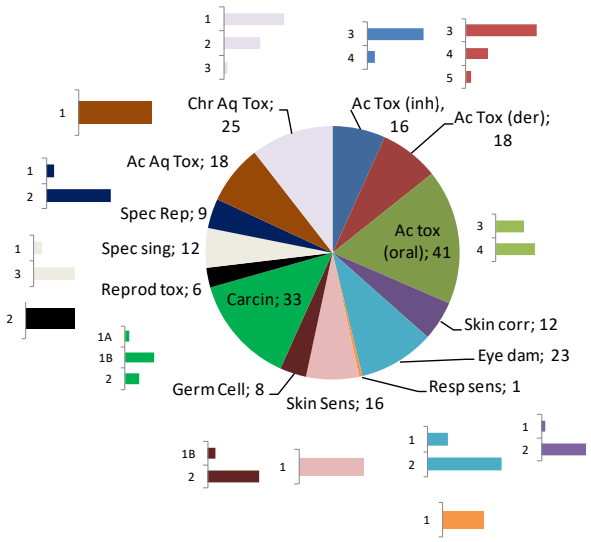
- Some phthlates are presumed to impair human fertility and cause harm to unborn children;
- Some phthlates are very toxic to acquatic organisms and may cause long-term adverse effects in the acquatic environment.

3. Brominated and Chlorinated Flame Retardants (57)



- Some flame retardants are presumed to impair human fertility and cause harm to unborn children;
- Some other flame retardants are presumed carcinogenic compounds;
- Some flame retardants are very toxic to acquatic organisms and may cause long-term adverse effects in the acquatic environment.

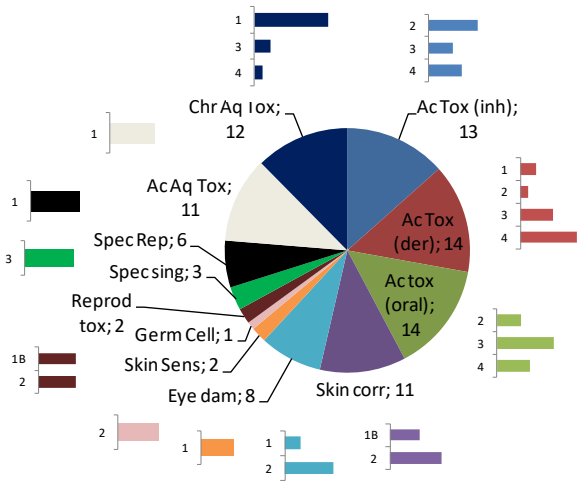
4. Dyes (73)



- Some azodyes are known carcinogenic for humans
- (4-aminodiphenyl, benzidine and 2-naphthylamine);
- Some other azodyes are presumed carcinogenic compounds or suspected to be toxic for reproduction;
- 4,4'-Oxydianiline is presumed to cause germ cell mutagenicity;
- Some azodyes may cause serious damage to human health, after short- and long-term exposure;
- Some azodyes are very toxic to acquatic organisms and may cause long-term adverse effects in the acquatic environment.

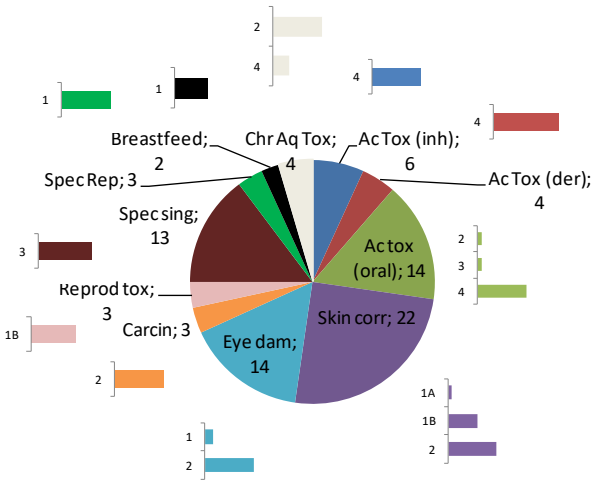
Table 1.6 (continued)

5. Organotin compounds (18)



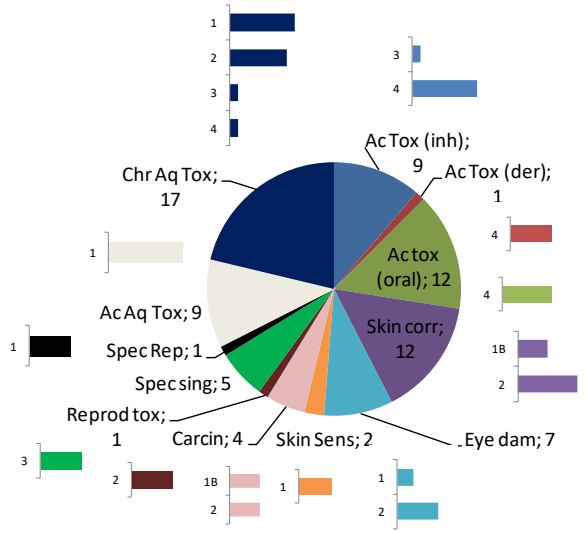
- Dibulthyltin dichloride is presumed to impair human fertility and to cause harm to unborn children;
- Tetraethyltin may be very toxic by skin contact;
- Some organotins may cause serious damage to human health after long-term exposure;
- Some organotins are very toxic to acquatic organisms and may cause long-term adverse effects in the acquatic environment.

6. Poly- and per-fluorinated chemicals (PFAS) (33)



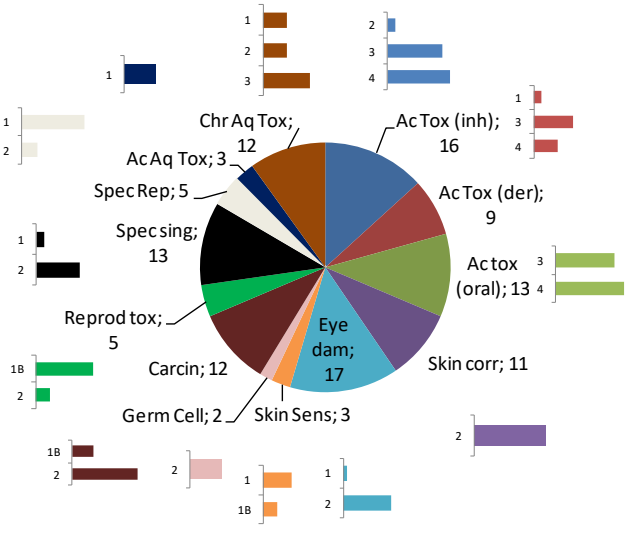
- PFOA and PFOS may cause serious damage to human health after long-term exposure, are presumed to impair human fertility and to cause harm to unborn children and are suspected carcinogenic.

7. Chlorobenzenes and chlorotoluenes (28)



- Some chlorobenzenes are presumed carcinogenic compounds;
- Hexachlorobenzene may cause serious damage to human health after long-term exposure;
- Some chlorobenzenes may be very toxic to acquatic organisms and may cause long-term adverse effects in the acquatic environment.

8. Solvents (23)



- TeCA is very toxic for humans by skin contact;
- Some solvents are presumed carcinogenic compounds;
- 1,2,3-TCP is presumed to impair human fertility and to cause harm to unborn children;
- Some solvents may cause serious damage to human health, after short- and long-term exposure.

Table 1.6 (continued)

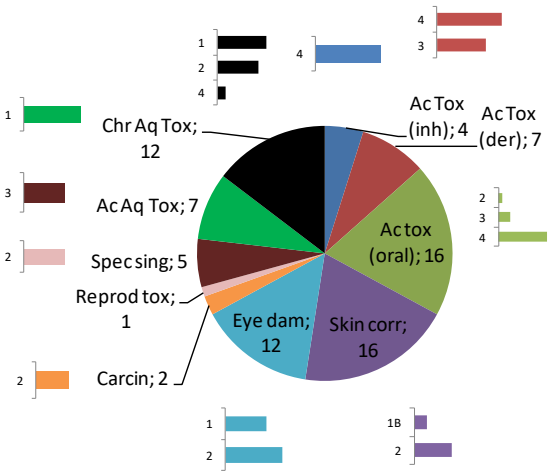
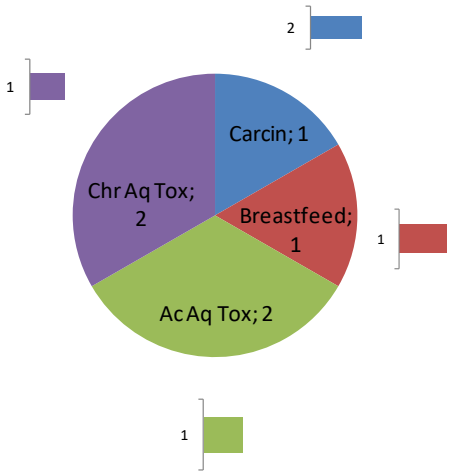
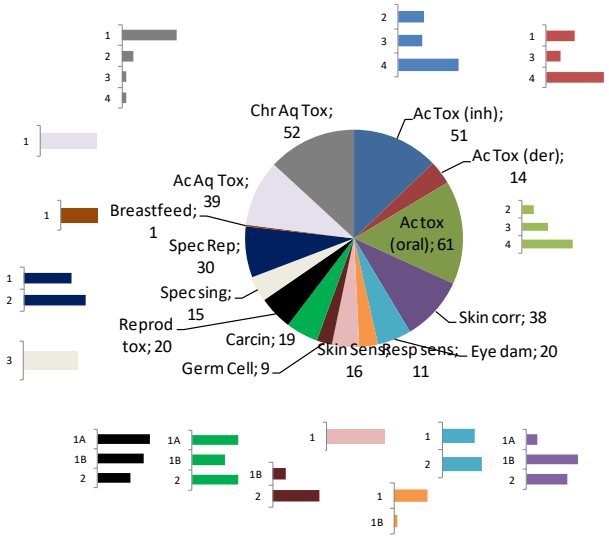
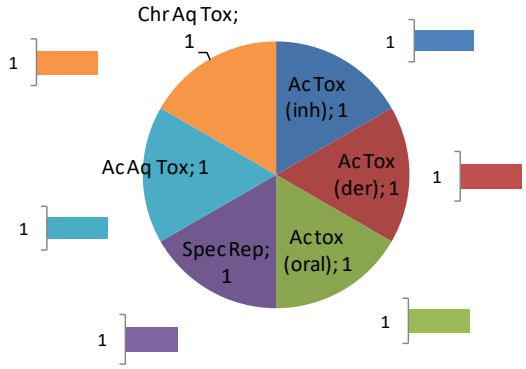
9. Phenols (20)	10. Short-Chain Chlorinated Paraffins (SCCPs) (2)
	
▪ PCP and 2,4,6-TriCP are suspected to be carcinogenic; ▪ Some chlorophenols may be very toxic to acquatic organisms and may cause long-term adverse effects in the aquatic environment.	▪ SCCPs (C10-C13) are suspected to be carcinogenic; ▪ SCCPs (C14-C17) may interefere on or via lactation; ▪ SCCPs are very toxic to acquatic organisms, may cause long-term adverse effects in the acquatic environment.
11. Metals and metalloids (104)	**12. Cyanide (1)**
	
▪ Some metals may cause serious damage to human health after long-term exposure; ▪ Some metals are known carcinogenic for humans; some other species are probable or suspect carcinogenic compounds; ▪ Some metals are known to impair human fertility or to cause harm to unborn children; some metals interefere on or via lactation; ▪ Metals may be very toxic to acquatic organisms and may cause long-term adverse effects in the acquatic environment.	▪ Sodium cyanide is very toxic by inhalation, skin contact and oral exposure; ▪ Sodium cyanide may cause serious damage to human health after long-term exposure; ▪ Sodium cyanide is very toxic to acquatic organisms and may cause long-term adverse effects in the acquatic environment.

Table 1.6 (continued)

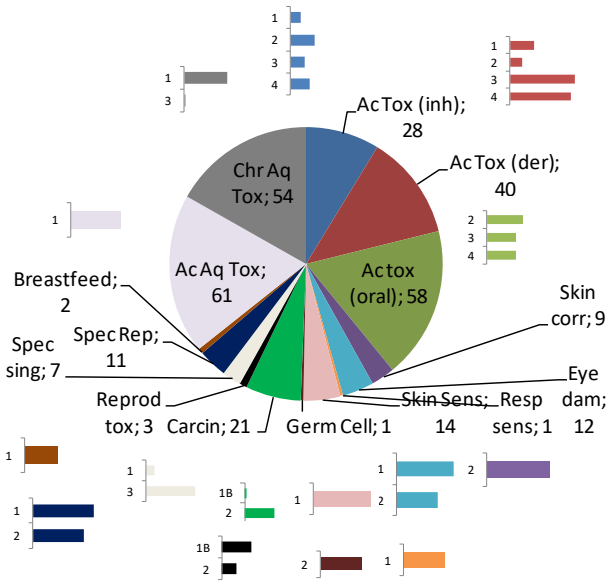
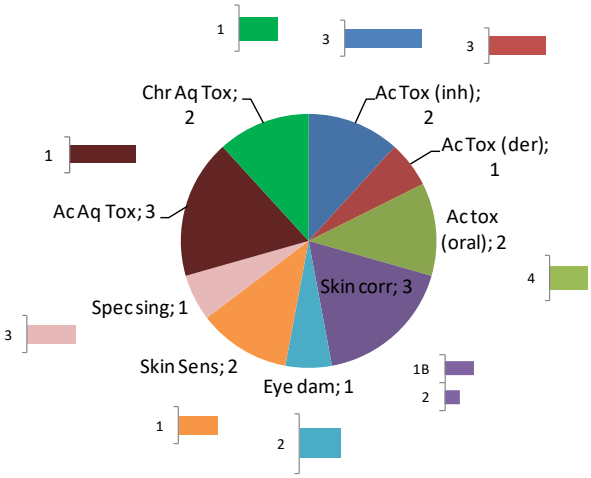
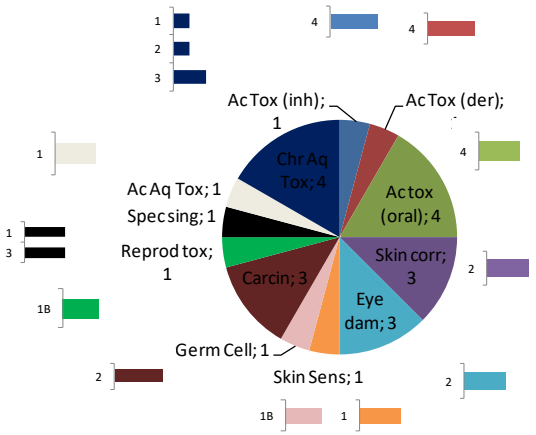
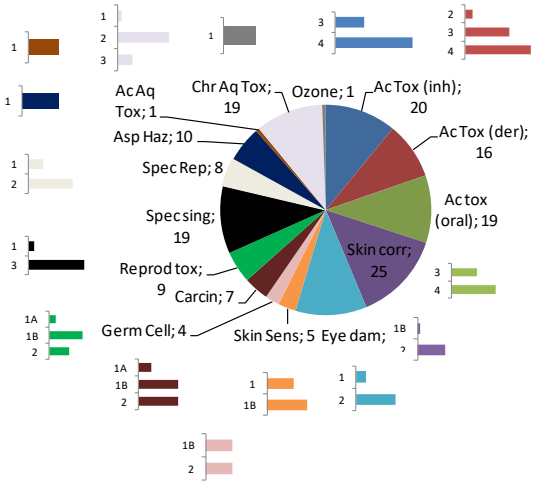
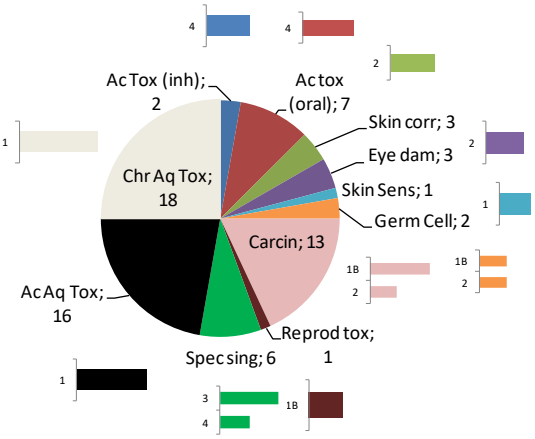
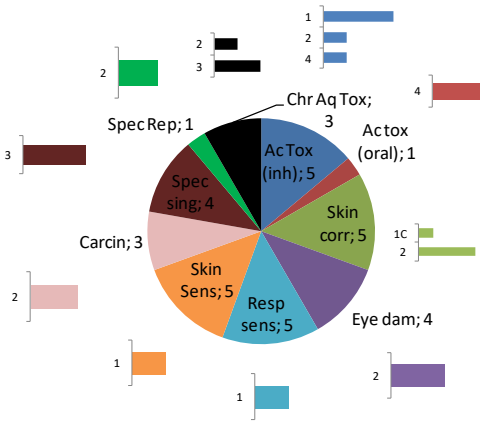
13. Pesticides (65)	14. Biocidics (3)
	
▪ Some pesticides are toxic for humans at low concentration, via inhalation and by skin contact; ▪ Some pesticides may cause serious damage to human health after short- and long-term exposure; ▪ Captafol is a presumed carcinogenic compound; some other pesticides are suspected to be carcinogenic; ▪ Dinoseb is known to impair human fertility or to cause harm to unborn children; other pesticides may interefere on or via lactation; ▪ Pesticides may be very toxic to acquatic organisms and may cause long-term adverse effects in the acquatic environment.	▪ Biocidics may be very toxic to acquatic organisms and may cause long-term adverse effects in the acquatic environment.

Table 1.6 (continued)

15. Organic phosphor acetic acid esters (9)	16. VOCs - Volatile Organic Compounds (49)
	
▪ Trimethylphosphate is a presumed germ cell mutagenic compound; ▪ Tris(2-chloroethyl) phosphate is known to impair human fertility or to cause harm to unborn children; ▪ Tris(2-buthoxyethyl) phosphate may cause serious damage to human health after short-term exposure; ▪ Some species may be very toxic to acquatic organisms and may cause long-term adverse effects in the acquatic environment.	▪ Benzene is a well known carcinogenic compound; ▪ 1,2-Dibromo-3-chloropropane is known to impair human fertility or to cause harm to unborn children; ▪ Some VOCs are known germ cell mutagenic compounds; ▪ Some VOCs may cause serious damage to human health after short- and long-term exposure; ▪ Some VOCs may be very toxic to acquatic organisms and may cause long-term adverse effects in the acquatic environment; they may also be hazardous for the ozone layer.
17. PAHs - Polycyclic aromatic hydrocarbons (21)	**18. Diisocyanates (5)**
	
▪ Some PAHs are presumed carcinogenic compounds; ▪ Benzo(a)pirene is a presumed germ cell mutagenic compound and is presumed also to impair human fertility or to cause harm to unborn children; ▪ Almost all PAHs are very toxic to acquatic organisms and may cause long-term adverse effects in the acquatic environment.	▪ Some diisocyanates are very toxic for humans via inhalation; ▪ Some diisocyanates are suspected to be carcinogenic compounds.

In order to better compare the most important toxicological characteristics of various classes of analytes, some types of harzard were selected: cancerogenicity, acute toxicity and toxicity for reproduction. For each class of analytes and for each type of hazard, the fraction of toxic compounds over the total of the investigated compounds was calculated. The fraction for acute toxicity was calculated including the three exposition routes (oral, inhalation, dermic).

Table 1.5. Fraction (%) of toxic compounds over the total of the investigated compounds. Acute toxicity includes the three exposition routes (oral, inhalation, dermic).

	Cancerogenicity			Acute toxicity					Toxic for reproduction		
	Known	Presum	Suspect	1	2	3	4	5	Known	Presum	Suspect
01. Alkylphenols	0%	0%	0%	0%	0%	0%	29%	0%	0%	0%	25%
02. Phthalates	0%	0%	0%	0%	0%	0%	0%	0%	0%	50%	9%
03. Flame Retardants	0%	14%	9%	0%	0%	0%	18%	8%	0%	5%	4%
04. Dyes	4%	27%	14%	0%	0%	20%	14%	0%	0%	0%	8%
05. Organotin Compounds	0%	0%	0%	4%	19%	26%	28%	0%	0%	6%	6%
06. PFOA	0%	0%	9%	0%	1%	1%	22%	0%	0%	9%	0%
07. Chlorobenzenes &CT	0%	7%	7%	0%	0%	1%	25%	0%	0%	0%	4%
08. Solvents	0%	13%	39%	1%	1%	26%	20%	0%	0%	4%	4%
09. Phenols	0%	0%	10%	0%	2%	10%	33%	0%	0%	0%	5%
10. SCPPs	0%	0%	50%	0%	0%	0%	0%	0%	0%	0%	0%
11. Metals and metalloids	7%	5%	7%	1%	6%	10%	23%	0%	8%	7%	5%
12. Cyanide	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%
13. Pesticides	0%	2%	31%	5%	18%	21%	21%	0%	0%	3%	2%
14. Biocidics	0%	0%	0%	0%	0%	33%	22%	0%	0%	0%	0%
15. OPAAEs	0%	0%	33%	0%	0%	0%	26%	0%	0%	11%	0%
16. VOCs	2%	6%	6%	0%	1%	13%	27%	0%	2%	16%	6%
17. PAHs	0%	43%	19%	0%	0%	0%	14%	0%	0%	5%	0%
18. Diisocyanates	0%	0%	60%	20%	7%	0%	13%	0%	0%	0%	0%

From the comparison given in Table 1.5 results that:

- dyes (C04), metals and metalloids (C11) and VOCs (C16) are the classes which have the relative highest number of known carcinogens;
- almost half of PAHs (C17) are presumed carcinogens;
- the most important classes characterised by acute toxicity are cyanide (C12), organotin compounds (C05) and pesticides (C13);
- considering all the categories, almost all classes have a relative high number of components characterised by acute toxicity;
- metals and metalloids (C11) is the class with the relative highest number of know toxics for reproduction
- phthalates (C02) is the class with the relative highest number of presumed toxics for reproduction.

1.4. Toxicity data elaboration

For the calculation of AGTS the level of toxicity, represented in GHS by the category, must be converted in a numerical value ranging from 0 (no toxicity) to 1 (maximum toxicity, always associated to category 1). When available, the converted values were established based on the "converted toxicity point estimates", used in the classification of mixture within GHS. Substances which cause effect on or via lactation were

assigned a value of 0.1 (reproductive toxicity). All converted values are reported in the Annex "Toxicity information" (Table A4).

The relative importance of the types of hazards was estimated following an integrated approach, which takes into consideration three aspects at the same time:

- Type of damage: hazards which cause very serious or lethal effects (such as acute toxicity or carcinogenicity) were always assigned the highest importance, followed by hazards which cause serious damage (such as reproductive toxicity, germ cell mutagenicity or specific target organ toxicity) and other minor hazards (skin corrosion, eye damage, aspiration hazard, sensitisation).
- Type of effect: health hazards and environmental hazards were considered almost at the same level of importance, with a small preference for the health effect, depending on the type of damage caused. As an example, acute toxicity was always assigned a higher importance than environmental hazards, while usually environmental hazards were considered more important than minor health hazards (such as sensitisation). Physical hazards were not considered in this evaluation, because the corresponding damage is caused by the manipulation or use of the substance in the original form, on the contrary compounds are diluted in water or distributed in textiles or accessories in the analysed sample.
- Exposition route: the relative importance is strictly related to the type of analysed sample.
    - For wastewater, types of hazards which can cause damage by ingestion was assigned a higher degree of importance, than those characterised by a different exposition route; ihnalation and dermal exposition were considered almost at the same level.
    - For clothing the order is the opposite, with the highest importance for dermic exposition, followed by inhalation and ingestion.

In Table 1.6 and Table 1.7 the established importance of the types of toxicity in the samples is reported. The degree of importance is normalised, so the sum of all values is 1000.

Table 1.6. Relative importance of the types of toxicity, in wastewater samples.

Type of toxicity	Importance
Acute toxicity (oral)	461
Carcinogenicity	323
Mutagenicity	185
Reproductive toxicity Specific organ toxicity	19
Acute acquatic toxicity	2.3
Acute toxicity (inhalation)	4.6
Chronic acquatic toxicity	1.2
Aspiration hazard	2.3
Acute toxicity (dermal)	1.2
Hazard to the ozone layer	0.5
Skin corrosion Eye damage	0.7
Respiratory sensitization Skin sensitization	0.2

Table 1.7. Relative importance of the types of toxicity, in clothing samples.

Type of toxicity	Importance
Acute toxicity (dermal)	407
Carcinogenicity	286
Mutagenicity	163
Acute toxicity (inhalation)	82
Reproductive toxicity Specific organ toxicity	16
Acute acquatic toxicity	4.1
Skin corrosion	2.0
Chronic acquatic toxicity	1.2
Skin sensitization	1.6
Aspiration hazard	1.0
Acute toxicity (oral)	1.0
Eye damage	0.6
Hazard to the ozone layer	0.5
Respiratory sensitization	0.2

2. WASTEWATER

2.1. Ranking of analytes

For every compound analysed in wastewater, the Analyte Global Toxicity Score (AGTS) was calculated as the sum of all the converted values - representing the categories of hazards - each weighted for the importance of its type of hazard, specific for wastewater (Table 1.6). The resulting scores are reported in Table 2.1.

The most toxic analytes in wastewater are cyanide, arsenic (As) and hexavalent chromium (Cr VI). This result is due to the choise of assigning the maximum relative importance to acute toxicity and carcinogenicity. Indeed, cyanide is classified as category 1 for acute toxicity (considering all the exposition routes); arsenic species are less dangerous in the short-term (category 2 or 3 for oral acute toxicity) but some of them are known carcinogenic compounds; hexavalent chromium shows also carcinogenic effects (category 1) and is an acute toxic by ingestion, category 3.

Table 2.1. Ranking of analytes, with internal code for classification (A), based on the Analyte Global Toxicity Score (AGTS), for wastewater.

	A	Analyte	AGTS
1	A1201	Cyanide	489
2	A1108	Arsenic (As)	373
3	A1102	Hexavalent chromium (Cr VI)	367
4	A1105	Nickel (Ni)	350
5	A1104	Cobalt (Co)	332
6	A0402	Benzidine	327
7	A0404	2-Naphthylamine	323
8	A0401	4-Aminodiphenyl	323
9	A1109	Cadmium (Cd)	77
10	A1111	Mercury (Hg)	73
11	A0706	Hexachlorobenzene	54
12	A0409	4,4'-Diaminodiphenylmethane	51
13	A0902	Dichlorophenol (DiCP)	47
14	A0911	2,4-Dichlorophenol, 2,5-Dichlorophenol, 2,6-Dichlorophenol, 3,5-Dichlorophenol	46
14	A0921	2,4-Dichlorophenol	46
16	A0614	Perfluorononanoic acid (PFNA)	46
17	A1112	Lead (Pb)	42
18	A0301	Polybromodiphenyls (PBBs)	39
19	A0312	Tri-bromo-diphenyl	39
20	A0311	Di-bromo-diphenyl	39
21	A0403	4-Chloro-o-toluidine	38
22	A0418	o-Toluidine	38
23	A0410	3,3'-Dichlorobenzidine	36
24	A0413	3,3'-Dimethyl-4,4'-diaminodiphenylmethane	36
25	A0415	4,4'-Methylene-bis(2-chloroaniline)	36
26	A0422	4-Aminoazobenzene	36
27	A0419	2,4-Toluenediamine	35
28	A0302	Tri-(2,3-di-bromo-propyl)-phosphate (TRIS)	35
29	A0421	o-Anisidine	35
30	A0804	1,2-Dichloroethane	34
31	A0414	p-Cresidine	33
32	A0813	Trichloroethylene	33
33	A0408	2,4-Diaminoanisole	33
34	A0314	Penta-bromo-diphenyl	33
35	A0412	3,3'-Dimethylbenzidine	33
35	A0417	4,4'-Thiodianiline	33
37	A0315	Hexa-bromo-diphenyl	33
37	A0319	Deca-bromo-diphenyl	33
39	A0411	3,3'-Dimethoxybenzidine	33
40	A0405	o-Aminoazotoluene	33
41	A0502	Dibutyltin (DBT)	27
42	A0425	Aniline	26
43	A0426	1,4-Phenylenediamine	25
44	A0504	Tributyltin (TBT)	25
45	A0510	Tetrabutyltin (TeBT)	25
46	A0416	4,4'-Oxydianiline	25
47	A0601	Perfluoro-n-octanoic acid (PFOA)	22
48	A0627	Perfluorooctane sulfonic acid	21
49	A0803	Carbon tetrachloride	21
50	A0602	Perfluorooctane sulphonates (PFOS)	21
51	A0805	1,1,1-Trichloroethane	21
52	A0802	Trichloromethane / Chloroform	20
53	A0809	Pentachloroethane	19
54	A0433	p-Toluidine	7.4
55	A0427	2-Chloroaniline	6.6
56	A0505	Triphenyltin (TPhT)	6.6
57	A0904	Tetrachlorophenols (TeCP)	6.5
58	A0917	2,3,4,6-Tetrachlorophenol	6.5
59	A0432	n-Methylaniline	5.9
60	A0508	Tripropyltin (TPT)	5.9
61	A0916	2,3,4,5-Tetrachlorophenol	5.3
62	A0201	Benzyl-butyl-phthalate (BBP)	5.3
62	A0210	Di-iso-butyl-phthalate (DIBP)	5.3
64	A0903	Trichlorophenols (TCP)	5.0
65	A0702	Dichlorobenzenes	5.0
66	A0914	2,4,6-Trichlorophenol	4.9
67	A0716	1,3-Dichlorobenzene, 1,4-Dichlorobenzenes	4.9
68	A1106	Copper (Cu)	4.9
69	A1107	Zinc (Zn)	4.9
70	A0707	1,2-Dichlorobenzene	4.9
71	A0429	m-Toluidine	4.7

Table 2.1. (continued)

	A	Analyte	AGTS
72	A0703	Trichlorobenzenes	4.7
72	A0915	3,4,5-Trichlorophenol, 2,3,4-Trichlorophenol	4.7
72	A0920	3,4,5-Trichlorophenol	4.7
75	A0104	Nonylphenolethoxylates (NPEOs)	4.6
76	A0912	2,3,5-Trichlorophenol	4.6
76	A0913	2,4,5-Trichlorophenol	4.6
78	A0905	Pentachlorophenol (PCP)	4.5
79	A0709	1,4-Dichlorobenzene	4.5
80	A0216	Di-iso-pentyl-phthalate (DIPP)	4.4
81	A0101	Octylphenols (OPs)	4.2
82	A0202	Di-butyl-phthalate (DBP)	4.2
82	A0218	1,2-Benzene-di-carboxylic acid di-pentyl-esters, branched and linear (DnPP)	4.2
82	A0219	N-iso-pentyl-iso-pentyl-phthalate (nPIP)	4.2
85	A0103	Nonylphenols (NPs)	4.0
86	A0506	Tricyclohexyltin (TCyHT)	3.9
87	A0303	Polybromodiphenyl ethers (PBDEs)	3.9
88	A0711	1,2,4-Trichlorobenzene	3.9
89	A0704	Tetrachlorobenzenes	3.9
89	A0705	Pentachlorobenzene	3.9
89	A0713	1,2,3,4-Tetrachlorobenzene	3.9
89	A0714	1,2,3,5-Tetrachlorobenzene	3.9
89	A0715	1,2,4,5-Tetrachlorobenzene	3.9
89	A0717	1,2,3,5-Tetrachlorobenzene, 1,2,4,5-Tetrachlorobenzene	3.9
95	A1110	Antimony (Sb)	3.8
96	A1001	Short-chain chlorinated paraffins (C10-C13)	3.8
97	A0324	Penta-bromo-diphenyl-ether (PentaBDE)	3.5
98	A0310	Bromo-diphenyl	3.5
99	A0306	Hexa-bromo-cyclo-dodecan (HBCDD)	3.5
100	A0206	Di-iso-decyl-phthalate (DIDP)	3.5
100	A0304	Tetra-bromo-bisphenol-A (TBBPA)	3.5
102	A0313	Tetra-bromo-diphenyl	3.4
103	A0810	1,1-Dichloroethylene	3.3
104	A1103	Manganese (Mn)	3.1
105	A0615	Perfluorodecanoic acid (PFDA)	3.0
105	A0918	2,3,5,6-Tetrachlorophenol	3.0
107	A0406	2-Amino-4-nitrotoluene	2.8
108	A0308	Tris-(2-chloro-ethyl)-phosphate (TCEP)	2.7
109	A0423	2,4-Xylidine	2.6
109	A0430	n,n-Diethylaniline	2.6
111	A0431	n-Ethylaniline	2.4
112	A0407	p-Chloroaniline	2.3
113	A0102	Octylphenolethoxylates (OPEOs)	2.3
114	A0203	Di-(2-ethyl-hexyl)-phthalate (DEHP)	1.8
114	A0212	Di-n-hexyl-phthalate (DNHP)	1.8
114	A0215	Bis-(2-methoxy-ethyl)-phthalate (DMEP)	1.8
114	A0217	Di-iso-heptyl-phthalate (DIHP)	1.8
118	A0808	1,1,2,2-Tetrachloroethane	1.7
119	A0807	1,1,1,2-Tetrachloroethane	1.5
120	A0307	2,2-Bis(bromomethyl)-1,3-propanediol (BBMP)	1.5
121	A0814	Tetrachloroethylene	1.4
122	A0710	1,2,3-Trichlorobenzene	1.3
123	A1101	Chromium (Cr)	1.2
124	A0712	1,3,5-Trichlorobenzene	1.2
125	A0608	N-Methyl-perfluorooctanesulfonamide (N-Me-FOSA)	1.2
125	A0610	N-Methyl-perfluorooctanesulfonamidoethanol (N-Me-FOSE)	1.2
127	A0616	Perfluoroundecanoic acid (PFUnA)	1.2
128	A0611	N-Ethyl-perfluorooctanesulfonamidoethanol (N-Et-FOSE)	1.2
128	A0620	Perfluorohexanesulfonic acid (PFHxS)	1.2
128	A0919	2,3,4-Trichlorophenol	1.2
131	A0910	3,4-Dichlorophenol	1.2
132	A0801	Dichloromethane	1.1
133	A0424	2,6-Xylidine	0.95
134	A0806	1,1,2-Trichloroethane	0.89
135	A0625	Perfluoro-3-7-dimethyl octane carboxylate	0.74
136	A0220	Di-heptyl-phthalate (DHP)	0.73
137	A0507	Trioctyltin (TriOT)	0.72
138	A0211	Di-cyclo-hexyl-phthalate (DCHP)	0.71
138	A0428	5-Nitro-o-anisidine	0.71

Table 2.1. (continued)

	A	Analyte	AGTS
138	A0604	Perfluorohexane sulphonates (PFHxS)	0.71
138	A0617	Perfluorododecanoic Acid (PFDoA)	0.71
138	A0624	2H,2H,3H,3H-Perfluoroundecanoic acid (H4PFUnA)	0.71
143	A0909	2,3-Dichlorophenol	0.69
144	A0605	Perfluorobutanoic acid (PFBA)	0.69
145	A0924	3,5-Dichlorophenol	0.63
146	A0901	Monochlorophenols (MCP)	0.61
146	A0906	2-Chlorophenol	0.61
146	A0907	3-Chlorophenol	0.61
146	A0908	4-Chlorophenol	0.61
150	A0701	Monochlorobenzene	0.60
151	A0609	N-Ethyl-perfluorooctanesulfonamide (N-Et-FOSA)	0.58
152	A0708	1,3-Dichlorobenzene	0.58
153	A0501	Monobutyltin (MBT)	0.52
154	A0606	Perfluoro-butane-sulfonic acid	0.50
155	A0613	Perfluoroheptanoic acid (PFHpA)	0.50
156	A0626	7H-Dodecafluoro heptane carboxylate	0.50
157	A0922	2,5-Dichlorophenol	0.50
158	A0320	Bromo-diphenyl-ether	0.46
159	A0305	Bis-(2,3-di-bromo-propyl)-phosphate	0.46
160	A0331	Tris-(2-chloroisopropyl)-phosphate (TCPP)	0.46
161	A0309	Tris-(1,3-di-chloro-iso-propyl)-phosphate (TDCPP)	0.44
162	A0209	Di-n-propyl-phthalate (DPP)	0.13
163	A0603	Perfluoro-n-hexanoic acid (PFHxA)	0.03
163	A0612	Perfluoropentanoic acid (PFPeA)	0.03
163	A0623	1H,1H,2H,2H-Perfluorooctanesulphonic acid (1H,1H,2H,2H-PFOS)	0.03
163	A0811	cis-1,2-Dichloroethylene	0.03
163	A0812	trans-1,2-Dichloroethylene	0.03
163	A0923	2,6-Dichlorophenol	0.03
169	A0607	Perfluorooctanesulfon amide (PFOSA)	0.01

	A	Analyte	AGTS
170	A0204	Di-n-octyl-phthalate (DNOP)	0
170	A0205	Di-iso-nonyl-phthalate (DINP)	0
170	A0207	Di-methyl-phthalate (DMP)	0
170	A0208	Di-ethyl-phthalate (DEP)	0
170	A0213	Di-nonyl-phthalate (DNP)	0
170	A0214	Di-iso-octyl-phthalate (DIOP)	0
170	A0316	Hepta-bromo-diphenyl	0
170	A0317	Octa-bromo-diphenyl	0
170	A0318	Nona-bromo-diphenyl	0
170	A0321	Di-bromo-diphenyl-ether	0
170	A0322	Tri-bromo-diphenyl-ether	0
170	A0323	Tetra-bromo-diphenyl-ether (TetraBDE)	0
170	A0325	Hexa-bromo-diphenyl-ether	0
170	A0326	Hepta-bromo-diphenyl-ether	0
170	A0327	Octa-bromo-diphenyl-ether	0
170	A0328	Nona-bromo-diphenyl-ether	0
170	A0329	Deca-bromo-diphenyl-ether	0
170	A0330	Tetra-bromo-bisphenol A bis-(di-bromo-propyl-ether) (TBBPA-BDPE)	0
170	A0332	Tris-(aziridinyl)-phosphinoxide (TEPA)	0
170	A0420	2,4,5-Trimethylaniline	0
170	A0503	Dioctyltin (DOT)	0
170	A0509	Monooctyltin (MOT)	0
170	A0618	Perfluorotridecanoic acid (PFTrA)	0
170	A0619	Perfluoro-tetradecanoic acid (PFTeA)	0
170	A0621	Perfluoroheptanesulfonic acid (PFHpS)	0
170	A0622	Perfluor-decane-sulfonic acid (PFDS)	0

In Table 2.2 the average AGTS for every class of compounds is reported. The most dangerous class is C12 (cyanide); the second most toxic class is C11 (metals and metalloids), especially due to the high toxicity of arsenic, hexavalent chromium, cadmium and nickel, included in the first five more toxic analytes in the list (Table 2.1).

Table 2.2. Ranking of class of analytes, based on the average Analyte Global Toxicity Score (AGTS, range in brackets), for wastewater.

	Class	Average AGTS (range)
C12	Cyanide	489
C11	Metals and metalloids	136 (1-373)
C04	Dyes	49 (0-327)
C08	Solvents	11 (0-34)
C05	Organotin Compounds	9.4 (0-27)
C03	Brominated and Chlorinated Flame Retardants	8.7 (0-39)
C09	Phenols	8.4 (0-47)
C07	Chlorobenzenes and chlorotoluenes	6.4 (0.6-54)
C06	Poly- and per-fluorinated chemicals (PFAS)	4.6 (0-46)
C10	Short-Chain Chlorinated Paraffins (SCCP)	3.8
C01	Alkylphenols	3.8 (2.3-4.6)
C02	Phthalates	2.0 (0-5.3)

2.2. Facility evaluation

Globally, 158 studies have been conducted in 4 years (42 in 2013, 43 in 2014, 40 in 2015, 33 in 2016). 140 manufacturing facilities, located in 12 countries, were involved. China is the most represented country, followed by Bangladesh, India, Turkey and Tunisia.

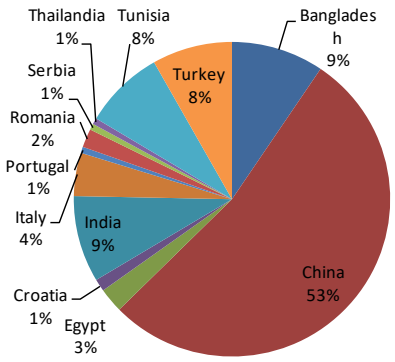


Figure 2.1. Facilities involved in this work, divided by country.

The evaluation conducted in this work includes three types of data of wastewater:

- incoming water (IW);
- untreated wastewater (UWW);
- treated wastewater (TWW).

Not all compounds of Table 2.1 were analysed in each facility and also there is a significant difference among the amount of data collected for the three types of sample, due to the monitoring strategy

adopted[2]. Specifically, from 98 to 158 compounds were analysed in every study, with an average of 146 of compounds per study. 36519 concentration values were used for the evaluation, divided into the three types of sample as follows: 8738 values for IW; 22997 values for UWW and 4784 values for TWW.

For every facility and for every type of sample a facility global score (FGTS) was calculated, applying the same equation used in the previous study[3], namely FGTS is the sum of the concentration of all analytes, weighted for their toxicity. For all analytes that have a concentration below the limit of detection (LOD), the half of LOD was assigned. All possible overlaps were taken into consideration: as an example, the concentration of total chromium (Cr) includes the concentration of hexavalent chromium (Cr VI), thus the concentration of Cr VI was substracted to the concentration of Cr. In other cases, if a group of compounds and single components of the group were analysed in the same facility, the information regarding the single components was preserved and the information regarding the group was discarded.

Based on the FGTS profile, facilities were classified into five impact categories, whose limits are listed in Table 2.3.

Table 2.3. Impact categories for wastewater samples, based on FGTS values.

Impact	FGTS
Minimum impact	From 0 to 30
Weak impact	From 30 to 65
Medium impact	From 65 to 120
Strong impact	From 120 to 260
Extreme impact	From 260 to 1000

Three rankings of analytes can be built from FGTS values reflecting the three types of sample (IW, UWW, TWW), to which the supplier responsibility ranking (SR) was added. SR was calculated by substracting the measured concentration in IW from the concentration in UWW, data by data, site by site. For those cases in which a value in UWW does not have a correspondence in IW, the missing data in IW was substituted with a value <LOD, therefore it was numerically considered half LOD.

All FGTS values of facilities are reported in the annex "Toxicity score WASTEWATER". All values associated to the four rankings are joined in the same column. Data is filterable based on several parametes, such as: type of measure (IW, UWW, TWW or SR), level of impact, year of the measure. The facility name is associated to an internal code (F code), composed by F and a three-digit number. Each study is represented by an internal code (S code), composed by S and a three-digit number, thus studies conducted in the same facility in different years are characterised by the same F code, but different S code. In the worksheet a link for the data file, namely the annex "Wastewater data", in the "Data wastewater" folder, was added. This file includes all available information about concentration data (analysis methods, laboratory name, report number, etc). When filtering data for a specific facility or study, the last columns on the right give the percentage of contribution of each data to the total of the facility/study, for the three types of sample.

[2] "Environmental impacts research and smart monitoring strategy development focused on the DETOX Programme", by E. Gregoris, M. Roman, A. Gambaro and C. Barbante, DAIS, Ca' Foscari University of Venice. Technical report, 2016. Pag. 15.

[3] "Environmental impacts research and smart monitoring strategy development focused on the DETOX Programme", by E. Gregoris, M. Roman, A. Gambaro and C. Barbante, DAIS, Ca' Foscari University of Venice. Technical report, 2016. Pag. 39.

A summary of the four rankings is reported in Table 2.4. As expected, facilities with strong and extreme impacts are present only in the UWW and SR rankings. UWW and SR rankings are very similar each other, as observed in the previous work[4].

Table 2.4. IW, UWW, TWW and SR rankings.

Impact	IW	UWW	TWW	SR
Extreme	0	2	0	2
Strong	0	1	0	1
Medium	0	3	1	2
Weak	1	10	1	9
Minimum	157	142	96	144

F096 (CHN) and F021 (CHN) are characterised by an extreme impact as untreated wastewater and supplier responsibility. Data related to these facilities were collected in 2013 and 2014, respectively. These facilities were in the two first positions also in the UWW and SR rankings of the previous work[5]. F060 (TUN, 2013) shows a strong impact in SR ranking; while the two facilities with medium impact in SR ranking (F132 (ITA) and F136 (HRV)) were both investigated in 2016.

In order to give an idea of FGTS values in the last year of analysis, all results of 2016 are reported in Figure 2.2. Of all 33 facilities investigated in 2016, only two of them (F136 and F132) show a medium impact, with FGTS values that can be considered extreme outliers, since they are significantly different from the distribution of data (following the quartile method for the definition of extreme outlier, described in the previous report[6]).

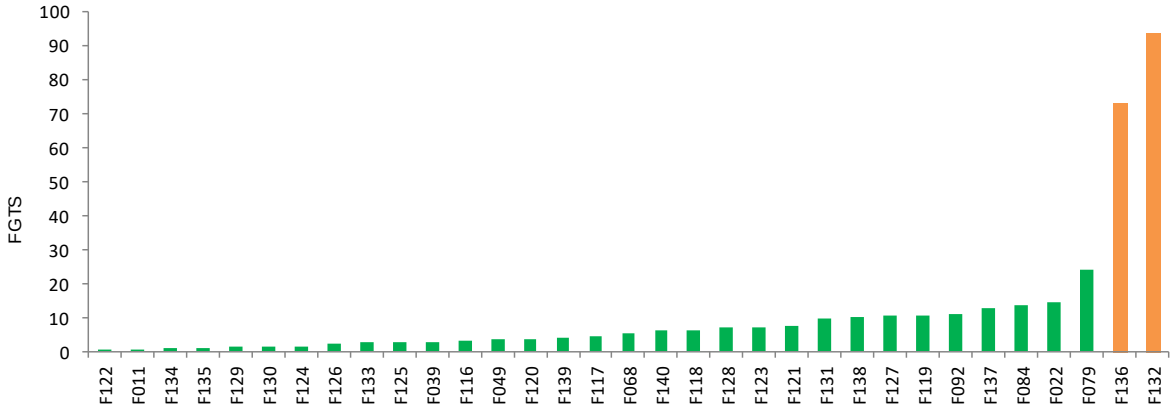


Figure 2.2. FGTS of facilities in SR ranking, in 2016.

[4] "Environmental impacts research and smart monitoring strategy development focused on the DETOX Programme", by E. Gregoris, M. Roman, A. Gambaro and C. Barbante, DAIS, Ca' Foscari University of Venice. Technical report, 2016. Pag. 52.

[5] "Environmental impacts research and smart monitoring strategy development focused on the DETOX Programme", by E. Gregoris, M. Roman, A. Gambaro and C. Barbante, DAIS, Ca' Foscari University of Venice. Technical report, 2016. Pag. 49.

[6] "Environmental impacts research and smart monitoring strategy development focused on the DETOX Programme", by E. Gregoris, M. Roman, A. Gambaro and C. Barbante, DAIS, Ca' Foscari University of Venice. Technical report, 2016. Pag. 27.

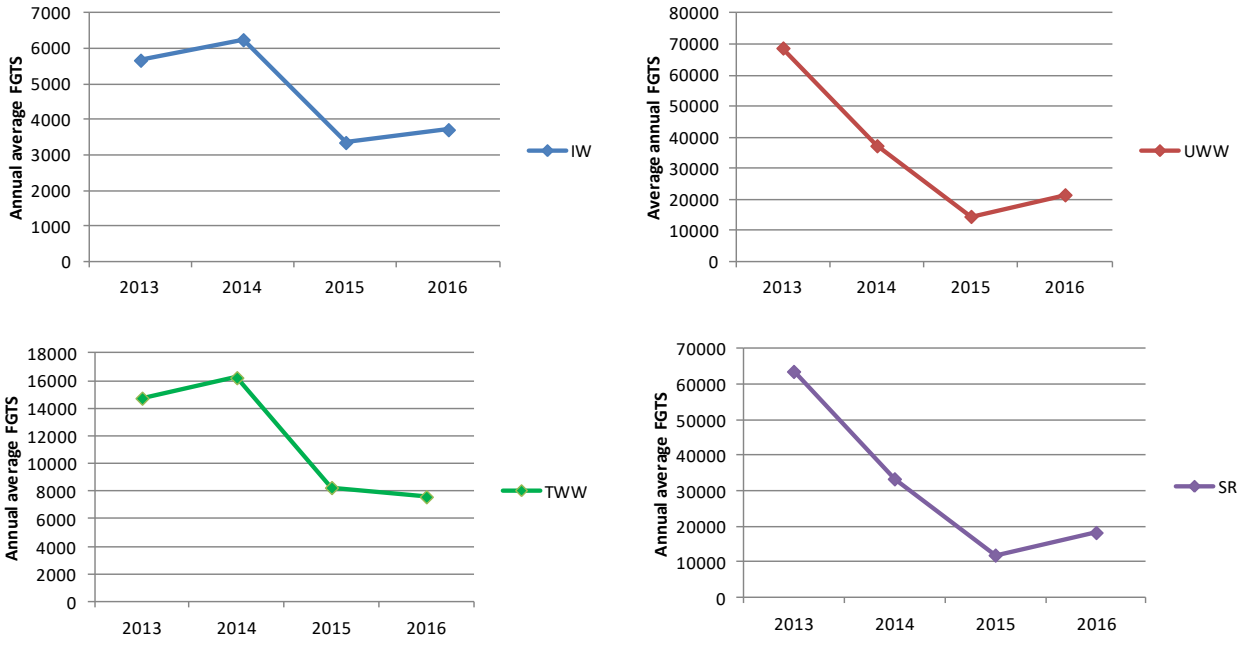


Figure 2.3. Chronogical trends of FGTS.

All rankings have a global decreasing chronological trend, with higher values of FGTS in 2013/14 and lower values in 2015/16 (Figure 2.3). UWW and SR, in particular, show a significant decrease from 2013 to 2015 (-80%), followed by an increase from 2015 to 2016 (about +50%), probably due to the weight of F132 and F136 FGTS values in the 2016 annual average. A comparison of FGTS scores - in SR ranking - of facilities which were repeatedly analysed over time is shown in Figure 2.4.

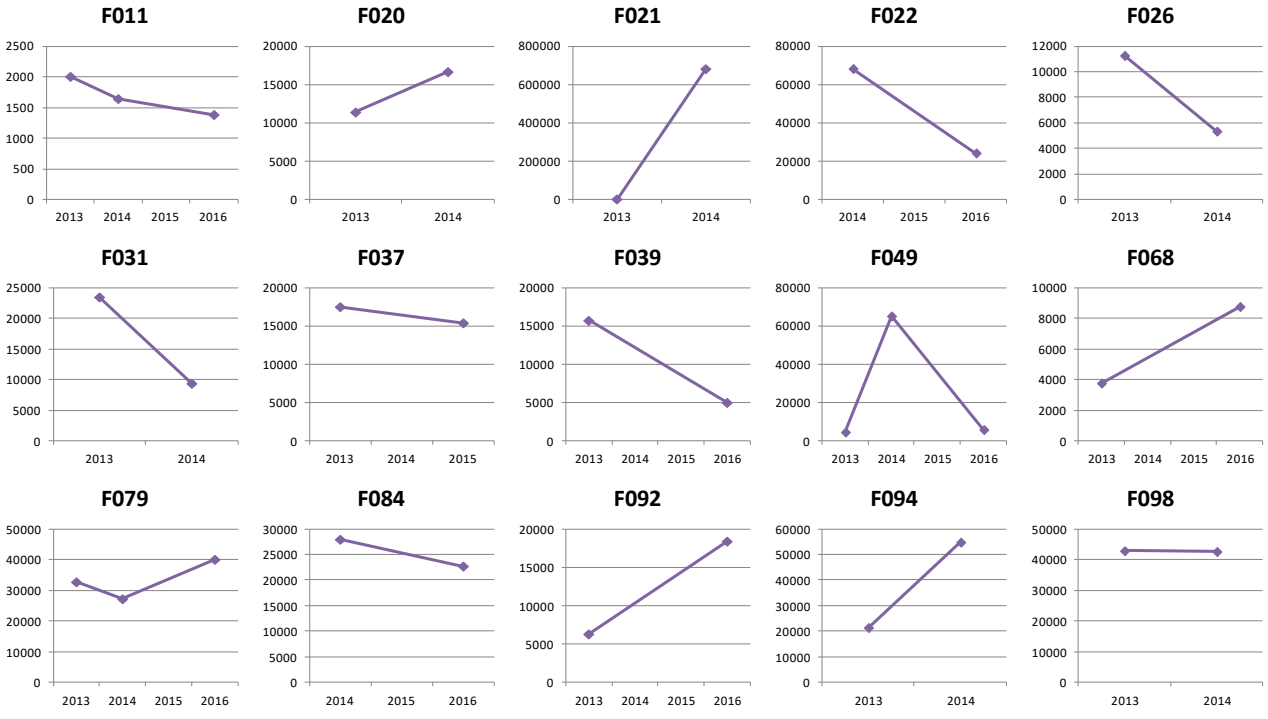


Figure 2.4. Choronogical trend of FGTS values - in SR ranking - of repeatedly investigated facilities.

A specific chronological trend for those facilities is not identificable. It must be reminded that the concentration data used is the result of a single analysis per year, thus could be largely influenced by the active manufacturing processes in the factory, in the period of sampling. Consequently, a comparison of annual means obtained with several analysis, though not referring to the same sites in different years, seems to be more appropriate.

Croatia is the country with the highest FGTS on average, as supplier responsibility, followed by China, Tunisia, Italia and India (Figure 2.5). The difference between this distribution and the previous one[7], can be mainly due to the results of the last year of analysis, not included in the previous evaluation. As mentioned before, the two facilities with higher FGTS in 2016 (F136 and F132) are in Croatia and Italy; they certainty contributed to the increased average FGTS of their countries. The high FGTS of F132 is manly due to the high concentration of cyanide (44%) and metals, as cobalt (19%), nickel (14%), zinc (12%) and copper (5%); while the most important contributors to FGTS of F136 are arsenic (51%) and nickel (37%) (Figure 2.6).

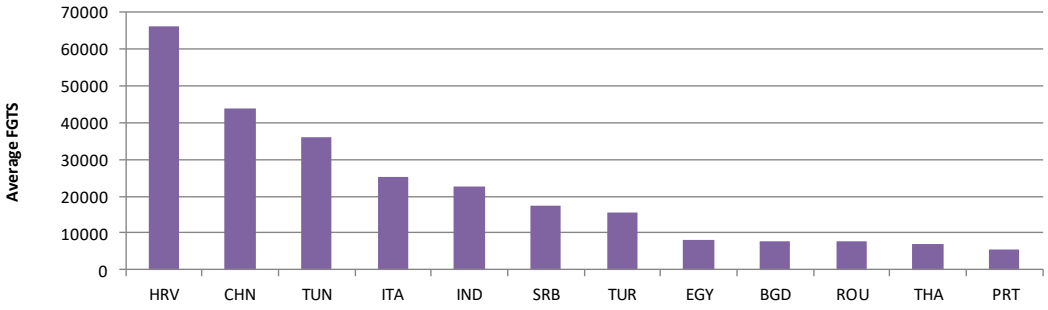


Figure 2.5. Average FGTS for countries - SR ranking.

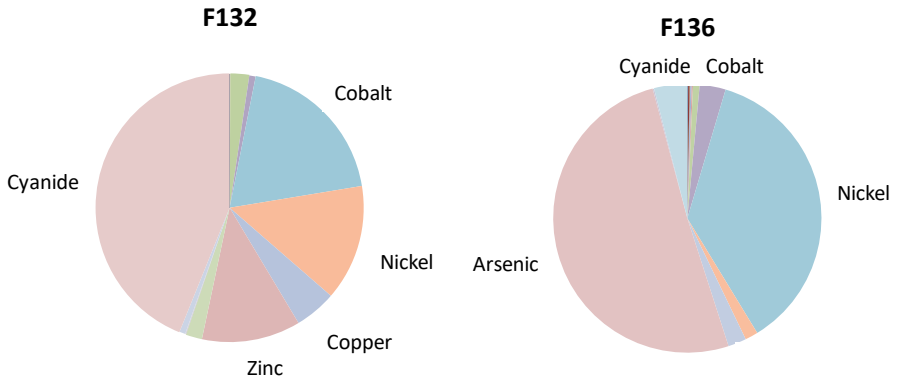


Figure 2.6. Contribution of chemicals to FGTS in two facilities with a medium impact as supplier responsibility, in 2016.

[7] "Environmental impacts research and smart monitoring strategy development focused on the DETOX Programme", by E. Gregoris, M. Roman, A. Gambaro and C. Barbante, DAIS, Ca' Foscari University of Venice. Technical report, 2016. Pag. 52.

3. CLOTHING

3.1. Ranking of analytes

For every compound analysed in clothing, AGTS was calculated as the sum of all the converted values - representing the categories of hazards - each weighted for the importance of its type of hazard, specific for clothing (Table 1.7). The resulting scores are reported in Table 3.1.

The most toxic compounds in clothing are lead (Pb) and mercury (Hg). A1119 represents a group of analytes (cadmium, hexavalent chromium, lead and mercury), thus it was assigned the highest category of each kind of toxicity of the members of the group, resulting in the same AGTS of lead.

This ranking is quite different from the ranking of wastewater (Table 2.1). Since dermal acute toxicity was considered the most important hazard for clothing (Table 1.7), arsenic - classified as acute toxic only by ingestion and inhalation - is not positioned in the very first part of the ranking for clothing. On the contrary, lead and mercury are characterised by a higher level of dermal acute toxicity (category 1) than their level of oral acute toxicity (category 4 and 2, respectively), thus explaining why they are raising their position in the ranking. Cyanide was never analysed in clothing (Table 1.2).

Table 3.1. Ranking of analytes, with internal code for classification (A), based on the Analyte Global Toxicity Score (AGTS), for clothing.

	A	Analyte	AGTS
1	A1112	Lead (Pb)	447
1	A1119	Heavy metals (Cd, Cr (VI), Pb, Hg)	447
3	A1111	Mercury (Hg)	441
4	A0515	Methyltin (MT)	439
5	A1308	Aldrin	431
5	A1329	Dieldrin	431
7	A0511	Tetraethyltin (TeEtT)	422
7	A1304	Isodrin	422
9	A0808	1,1,2,2-Tetrachloroethane	416
10	A1356	Phosdrin / Mevinphos	416
11	A1361	Strobane	414
12	A1362	Telodrin / Isobenzan	412
13	A1102	Hexavalent chromium (Cr VI)	344
14	A1642	Benzene	319
15	A1105	Nickel (Ni)	313
16	A1104	Cobalt (Co)	306
17	A1108	Arsenic (As)	293
18	A0402	Benzidine	292
19	A0404	2-Naphthylamine	286
20	A0401	4-Aminobiphenyl	285
21	A1328	Dicrotophos	129
22	A1306	Azinophos-methyl	98
23	A1359	Quinalphos	97
24	A1316	Chlorfenvinphos	96
25	A1801	2,4-Toluene diisocyanate (2,4-TDI)	84
26	A1805	Isophorone diisocyanate (IPDI)	84
27	A1804	Hexamethylene diisocyanate (HDI)	83
28	A1109	Cadmium (Cd)	77
29	A1637	1,2-Dibromo-3-chloropropane	63
30	A0822	1,2,3-Trichloropropane	58
31	A1601	Formaldehyde	57
32	A1713	Benzo(a)pyrene	54
33	A1348	Metamidophos	53
34	A0706	Hexachlorobenzene	51
35	A1336	Heptachlor	47
36	A0409	4,4'-Diaminodiphenylmethane	47
37	A0403	4-Chloro-o-toluidine	45
38	A1621	Hexachlorobutadiene	42
39	A0301	PBBs	41
40	A1352	Parathion	39
41	A0410	3,3'-Dichlorobenzidine	39
42	A1636	1,2-Dibromoethane	39
43	A0421	o-Anisidine	39
44	A0413	3,3'-Dimethyl-4,4'-diaminodiphenylmethane	36
45	A1310	Captafol	36
46	A1714	Benzo(g,h,i)perylene	35
47	A0425	Aniline	35
48	A0415	4,4'-Methylene-bis-(2-chloro-aniline)	35
49	A1710	Chrysene	35
50	A0422	4-Aminoazobenzene	35
50	A1709	Benzo(a)anthracene	35
50	A1711	Benzo(b)fluoranthene	35
50	A1712	Benzo(k)fluoranthene	35
50	A1716	Dibenzo(a,h)anthracene	35
50	A1717	Benzo(e)pyrene	35
50	A1718	Benzo(j)fluoranthene	35
50	A1724	Benzo(b)fluoranthene(BbF) and Benzo(j)fluoranthene(BjF)	35
58	A0502	Dibutyltin (DBT)	35
59	A0418	o-Toluidine	34
60	A0416	4,4'-Oxydianiline	34
61	A0426	1,4-Phenylenediamine	34
62	A0514	Trimethyltin (TMT)	33
63	A0302	TRIS	33
64	A0419	2,4-Toluenediamine	33
65	A0720	Trichlorotoluenes	31
66	A1324	DDT	31
67	A0434	Disperse Blue 1	31
68	A0804	1,2-Dichloroethane	30
69	A1363	Tolyfluanid	30
70	A0405	o-Aminoazotoluene	30
71	A0408	2,4-Diaminoanisole	29

Table 3.2. (continued)

	A	Analyte	AGTS
72	A0412	3,3'-Dimethylbenzidine	29
72	A0417	4,4'-Thiodianiline	29
74	A0813	Trichloroethylene	29
75	A0463	Direct black 38	29
76	A0457	Direct red 28	29
76	A0458	Direct blue 6	29
78	A0414	p-Cresidine	29
79	A0411	3,3'-Dimethoxybenzidine	29
80	A0461	Basic red 9	29
80	A0462	Basic violet 14	29
82	A0803	Carbon tetrachloride	27
83	A0504	Tributyltin (TBT)	26
84	A0805	1,1,1-Trichloroethane	26
84	A0818	1,1-Dichloropropene	26
84	A1313	Chlordane	26
87	A0509	Monooctyltin (MOT)	24
88	A0510	Tetrabutyltin (TeBT)	24
89	A1353	Parathion-methyl	23
90	A1319	Cyhalothrin	22
90	A1357	Propethamphos	22
92	A1351	Monocrotophos	21
93	A1644	2-Methoxyethanol	20
94	A0601	Perfluoro-n-octanoic acid (PFOA)	19
95	A0602	Perfluorooctane sulphonates (PFOS)	19
96	A0802	Chloroform	18
97	A1331	Dinoseb and its salts	18
98	A0433	p-Toluidine	18
99	A1404	2-Octyl-4-isothiazoline-3-one	18
100	A1303	Chlorthalonil	17
101	A0809	Pentachloroethane	17
102	A1633	Styrene	17
103	A1503	Trimethylphosphate	17
104	A0505	Triphenyltin (TPhT)	17
105	A0339	Tri-o-cresyl phosphate	17
106	A1332	alpha-Endosulfan	16
107	A0819	cis-1,3-Dichloropropene	16
107	A0820	trans-1,3-Dichloropropene	16
109	A0508	Tripropyltin (TPT)	16
110	A0513	Dimethyltin (DMT)	16
111	A1347	Mecoprop	15
112	A1314	Chlordecone / Kepone	15
113	A1307	Azinophos-ethyl	14
113	A1334	Endrin	14
115	A0904	Tetrachlorophenols (TeCP)	14
115	A0917	2,3,4,6-Tetrachlorophenol	14
115	A0927	Chlorinated Phenols	14
118	A0429	m-Toluidine	14
119	A1110	Antimony (Sb)	12
120	A1106	Copper (Cu)	11
121	A1116	Boron (B)	10
122	A1802	2,6-Toluene diisocyanate (2,6-TDI)	10
123	A1630	Phenol	10
124	A1358	Profenophos	10
125	A0406	2-Amino-4-nitrotoluene	10
126	A0423	2,4-Xylidine	10
127	A1321	Deltamethrin	10
128	A1364	Trifluralin	10
129	A1335	Fenvalerat / Esfenvalerate	9.4
130	A0903	Trichlorophenols (TriCP)	9.2
130	A0920	3,4,5-Trichlorophenol	9.2
132	A1113	Tin (Sn)	8.9
133	A1349	Methoxychlor	8.9
134	A1305	2,4-D	8.6
135	A1342	Lindane / g-HCH	8.6
136	A0506	Tricyclohexyltin (TCyHT)	8.6
137	A0902	Dichlorophenols (DCP)	8.6
137	A0911	2,4-Dichlorophenol, 2,5-Dichlorophenol, 2,6-Dichlorophenol, 3,5-Dichlorophenol	8.6
137	A0921	2,4-Dichlorophenol	8.6
140	A1649	o-Cresol	8.5

Table 3.2. (continued)

	A	Analyte	AGTS
141	A1107	Zinc (Zn)	8.5
142	A0924	3,5-Dichlorophenol	8.5
143	A1350	Mirex	8.5
144	A1322	DDD	8.4
144	A1339	alpha-Hexachlorcyclohexane	8.4
144	A1340	beta-Hexachlorcyclohexane	8.4
144	A1341	delta-Hexachlorcyclohexane	8.4
148	A1315	Chlordimeform	8.4
149	A1602	p-Cresol	8.3
149	A1648	m-Cresol	8.3
151	A1317	Coumaphos	8.3
152	A1320	Cypermethrin	8.2
153	A0702	Dichlorobenzenes	8.2
153	A0707	1,2-Dichlorobenzene	8.2
155	A1309	Bromophosethyl	8.2
156	A1355	Permethrin	8.2
157	A1318	Cyfluthrin	7.9
158	A1117	Selenium (Se)	7.8
159	A1344	Malathion	7.7
160	A0201	Benzyl-butyl-phthalate (BBP)	7.7
160	A0210	Di-iso-butyl-phthalate (DIBP)	7.7
160	A0221	Di-(2-ethyl-hexyl)-phthalate (DEHP) + Di-butyl-phthalate (DBP) + Benzyl-butyl-phthalate (BBP)	7.7
160	A0228	Di-(2-ethyl-hexyl)-phthalate (DEHP) + Di-butyl-phthalate (DBP) + Benzyl-butyl-phthalate (BBP) + Di-iso-butyl-phthalate (DIBP)	7.7
160	A0230	Phthalates	7.7
160	A1360	Quintozene	7.7
166	A1403	2-Methyl-4-isothiazolin-3-one	7.5
167	A0216	Di-iso-pentyl-phthalate (DIPP)	7.3
167	A0218	1,2-Benzene-di-carboxylic acid di-pentyl-esters, branched and linear (DnPP)	7.3
169	A0104	Nonylphenolethoxylates (NPEOs)	7.1
169	A0105	Alkylphenols ethoxylates	7.1
171	A0469	Basic violet 3	7.0
172	A0474	Basic green 4	6.7
173	A1345	MCPA	6.7
174	A0101	Octylphenols (OPs)	6.7
175	A0512	Diphenyltin (DPhT)	6.5
176	A1115	Barium (Ba)	6.5
177	A1337	Heptachlorepoxid	6.4
178	A0816	Hexachloroethane	6.4
178	A0905	Pentachlorophenol (PCP)	6.4
180	A0914	2,4,6-Trichlorophenol	6.4
180	A1323	DDE	6.4
182	A1701	Naphthalene	6.4
183	A0709	1,4-Dichlorobenzene	6.4
184	A1001	Short-chain chlorinated paraffins (C10-C13)	6.4
185	A0103	Nonylphenols (NPs)	6.2
186	A1301	2,4,5-T	6.1
187	A1625	m-/p-Xylene	6.1
187	A1626	Xylene (o-/m-/p-)	6.1
187	A1703	Acenaphthene	6.1
187	A1706	Anthracene	6.1
191	A0306	Hexa-bromo-cyclo-dodecan (HBCDD)	6.1
191	A0324	Penta-bromo-diphenyl-ether (PentaBDE)	6.1
193	A1333	beta-Endosulfan	6.1
194	A0912	2,3,5-Trichlorophenol	6.1
194	A0913	2,4,5-Trichlorophenol	6.1
194	A0703	Trichlorobenzenes	6.1
194	A0711	1,2,4-Trichlorobenzene	6.1
198	A1401	Triclosane	6.1
199	A1327	Dichlorfluanid	6.1
200	A1312	Chlorbenzilate	6.1
201	A0704	Tetrachlorobenzenes	6.1
201	A0705	Pentachlorobenzene	6.1
201	A0713	1,2,3,4-Tetrachlorobenzene	6.1
201	A0714	1,2,3,5-Tetrachlorobenzene	6.1
201	A0715	1,2,4,5-Tetrachlorobenzene	6.1
201	A1325	Diazinon	6.1

Table 3.2. (continued)

	A	Analyte	AGTS
201	A1705	Phenanthrene	6.1
201	A1707	Fluoranthene	6.1
209	A0206	Di-iso-decyl-phthalate (DIDP)	6.1
209	A0222	Di-iso-nonyl-phthalate (DINP) + Di-iso-decyl-phthalate (DIDP) + Di-n-octyl-phthalate (DNOP)	6.1
209	A0226	1,2-Benzenedicarboxylic acid, di-C7-11-branched and linear esters (DHNUP)	6.1
209	A0227	Di-C6-10 alkyl phthlates	6.1
209	A0304	Tetra-bromo-bisphenol-A (TBBPA)	6.1
209	A1002	Short-chain chlorinated paraffins (C14-C17)	6.1
209	A1346	MCPB	6.1
209	A1508	Triphenylphosphate	6.1
209	A1627	n-Butylbenzene	6.1
209	A1704	Fluorene	6.1
209	A1708	Pyrene	6.1
220	A0435	Disperse blue 3	5.7
221	A0202	Di-butyl-phthalate (DBP)	5.7
221	A0219	N-iso-pentyl-iso-pentyl-phthalate (nPIP)	5.7
221	A0223	Di-n-pentylphthalate (DnPP/DPP)	5.7
224	A1311	Carbaryl	4.8
225	A0916	2,3,4,5-Tetrachlorophenol	4.7
226	A0310	Bromo-diphenyl	4.7
227	A0721	Tetrachlorotoluenes	4.5
228	A0468	Basic violet 1	4.4
229	A0825	Orthophenylphenol	4.1
230	A1610	2-Ethoxyethylacetate	4.1
230	A1354	Pentachloroanisol	4.1
230	A0826	Dimethylformamide (DMFa)	4.1
230	A0828	Dimethylacetamide	4.1
234	A0806	1,1,2-Trichloroethane	4.0
235	A1643	Dimethylfumarate (DMFu)	3.9
236	A1624	o-Xylene	3.7
237	A1604	m-Xylene	3.5
238	A1608	2-Ethoxyethanol	3.3
239	A1101	Chromium (Cr)	3.2

	A	Analyte	AGTS
240	A1617	Cyclohexanone	3.1
241	A0424	2,6-Xylidine	3.0
242	A1723	Dibenzo(a,h)pyrene	2.7
243	A1103	Manganese (Mn)	2.7
244	A0102	Octylphenolethoxylates (OPEOs)	2.7
244	A0901	Monochlorophenols (MCP)	2.7
244	A0906	2-Chlorophenol	2.7
244	A0907	3-Chlorophenol	2.7
244	A0908	4-Chlorophenol	2.7
249	A1803	Diphenylmethane diisocyanate (MDI)	2.6
250	A0501	Monobutyltin (MBT)	2.5
251	A0712	1,3,5-Trichlorobenzene	2.5
252	A0471	Aminochlorophenols	2.5
252	A0608	N-Methyl-perfluorooctanesulfonamide (N-Me-FOSA)	2.5
252	A0610	N-Methyl-perfluorooctanesulfonamidoethanol (N-Me-FOSE)	2.5
255	A1507	Tris(2-buthoxyethyl)phosphate	2.5
256	A0616	Perfluoroundecanoic acid (PFUnA)	2.5
257	A1605	p-Xylene	2.4
258	A1114	Aluminium (Al)	2.4
259	A1622	Isophorone	2.3
260	A1720	Dibenzo(a,e)pyrene	2.3
261	A0609	N-Ethyl-perfluorooctanesulfonamide (N-Et-FOSA)	2.2
262	A0718	Chlorotoluenes	2.2
262	A0724	4-chlorotoluene	2.2
264	A0814	Tetrachloroethylene	2.1
265	A1502	Tri(2-chloroethyl)-phosphate	2.1
266	A0472	Navy blue	2.1
267	A1611	Benzaldehyde	2.0
268	A1330	Dimethoate	2.0
268	A0605	Perfluorobutanoic acid (PFBA)	2.0
270	A1647	Ethylene glycol dimethyl ether	2.0
271	A0451	Disperse yellow 3	1.9
272	A1616	Bromoform	1.8
273	A1505	Triisobutylphosphate	1.7

Table 3.2. (continued)

	A	Analyte	AGTS
273	A0444	Disperse orange 3	1.7
273	A0827	1-Methyl-2-pyrrolidone	1.7
276	A1638	1,2,4-Trimethylbenzene	1.7
277	A0441	Disperse blue 124	1.6
278	A1603	Triethylene glycol dimethyl ether	1.6
278	A0203	Di-(2-ethyl-hexyl)-phthalate (DEHP)	1.6
278	A0212	Di-n-hexyl-phthalate (DnHP)	1.6
278	A0215	Bis-(2-methoxy-ethyl)-phthalate (DMEP)	1.6
278	A0217	Di-iso-heptyl-phthalate (DIHP)	1.6
278	A0225	1,2-Benzenedicarboxylic acid, di-C6-8-branched alkyl esters, C7-rich (DIHP)	1.6
278	A0334	Bis(2-methoxyethyl)-ether	1.6
278	A0335	Diboron trioxide (BTO)	1.6
278	A0337	Boric acid (HB)	1.6
278	A0438	Disperse blue 35	1.6
278	A0445	Disperse orange 37 / 76 / 59	1.6
289	A0447	Disperse red 1	1.6
290	A1614	Bromochloromethane	1.4
291	A1620	Ethylbenzene	1.4
292	A0807	1,1,1,2-Tetrachloroethane	1.3
293	A1628	n-Hexane	1.3
293	A1623	Isopropylbenzene	1.2
295	A1629	n-Propylbenzene	1.2
296	A1631	p-Isopropyltoluene	1.2
297	A1326	Dichlorprop	1.1
298	A1635	Toluene	1.1
299	A1615	Bromodichloromethane	0.92
300	A0407	p-Chloroaniline	0.82
301	A0810	1,1-Dichloroethylene	0.70
302	A0918	2,3,5,6-Tetrachlorophenol	0.64
303	A0919	2,3,4-Trichlorophenol	0.63
304	A0723	2-Chlorotoluene	0.63
304	A0701	Monochlorobenzene	0.61
306	A0910	3,4-Dichlorophenol	0.61
307	A0442	Disperse brown 1	0.61
308	A0725	3-Chlorotoluene	0.61
309	A0309	Tris-(1,3-di-chloro-iso-propyl)-phosphate (TDCPP)	0.49
309	A0811	cis-1,2-Dichloroethylene	0.43
309	A0812	trans-1,2-Dichloroethylene	0.43
312	A1619	Dibromomethane	0.43
313	A1609	2-Ethyl-1-hexanol	0.43
314	A1612	tert-Butanol	0.42
315	A0821	1,2-Dichloropropane	0.41
315	A0719	Dichlorotoluenes	0.41
315	A0726	2,3-Dichlorotoluene	0.41
318	A0728	2,5-Dichlorotoluene	0.41
319	A0801	Dichloromethane	0.32
320	A1506	Tributylphosphate	0.31
321	A0307	2,2-Bis(bromomethyl)-1,3-propanediol (BBMP)	0.31
321	A0459	Acid red 26	0.29
321	A0470	Acid violet 49	0.29
324	A1715	Indeno(1,2,3-cd)pyrene	0.29
325	A0710	1,2,3-Trichlorobenzene	0.22
326	A1639	1,3,5-Trimethylbenzene	0.22
327	A0209	Di-n-propyl-phthalate (DPP)	0.22
327	A0729	2,6-Dichlorotoluene	0.21
327	A1613	Bromobenzene	0.21
330	A1632	sec-Butylbenzene	0.21
331	A0708	1,3-Dichlorobenzene	0.20
332	A0614	Perfluorononanoic acid (PFNA)	0.12
332	A0606	Perfluoro-butane-sulfonic acid	0.10
332	A0613	Perfluoroheptanoic acid (PFHpA)	0.10
335	A0922	2,5-Dichlorophenol	0.10
335	A0603	Perfluoro-n-hexanoic acid (PFHxA)	0.10
335	A0612	Perfluoropentanoic acid (PFPeA)	0.10
335	A0623	1H,1H,2H,2H-Perfluorooctanesulphonic acid (1H,1H,2H,2H-PFOS)	0.10
339	A0923	2,6-Dichlorophenol	0.10
340	A0817	1,1-Dichloroethane	0.04
341	A0220	Di-heptyl-phthalate (DHP)	0.04

Table 3.2. (continued)

	A	Analyte	AGTS
342	A0615	Perfluorodecanoic acid (PFDA)	0.02
343	A0507	Trioctyltin (TriOT)	0.02
343	A0448	Disperse red 11	0.02
343	A0611	N-Ethyl-Perfluorooctanesulfonamidoethanol (N-Et-FOSE)	0.02
343	A0620	Perfluorohexanesulfonic acid (PFHxS)	0.02
343	A1640	2-Phenyl-2-propanole	0.02
348	A1702	Acenaphthylene	0.02
348	A0211	Di-cyclo-hexyl-phthalate (DCHP)	0.02
348	A0436	Disperse blue 7	0.02
348	A0617	Perfluorododecanoic acid (PFDoA)	0.02
348	A0624	2H,2H,3H,3H-Perfluoroundecanoic acid (H4PFUnA)	0.02
348	A0629	1H,1H,2H,2H-Pefluoro-1-octanol (6:2 FTOH)	0.02
348	A0632	1H,1H,2H,2H-Perfluorooctylacrylate (6:2 FTA)	0.02
348	A0634	1H,1H,2H,2H-Perfluorododecylacrylate (10:2 FTA)	0.02
348	A0823	1,3-Dichloropropane	0.02
357	A1606	1-Methylpyrene	0.02
358	A0926	2,2'-Methylenebis(6-tert-butyl-p-cresol)	0.02
359	A1607	2-Butanone	0.02
360	A0338	Tetraboron disodium heptaoxide, hydrate (TBHO)	0.02
361	A0925	2,3,6-Trichlorophenol	0.004
362	A0909	2,3-Dichlorophenol	0.003
362	A0607	Perfluorooctanesulfonamide (PFOSA)	0.002
364	A1118	Strontium (Sr)	0.002
364	A0473	Basic blue 26	0.002
364	A1504	Triethylphosphate	0.002
367	A1641	Acetophenone	0.002
367	A0449	Disperse red 17	0.001
369	A1618	Dibromochloromethane	0.001
369	A0824	2,2-Dichloropropane	0.001
371	A1634	tert-Butylbenzene	0
371	A0204	Di-n-octyl-phthalate (DNOP)	0
371	A0205	Di-iso-nonyl-phthalate (DINP)	0
371	A0207	Di-methyl-phthalate (DMP)	0
371	A0208	Di-ethyl-phthalate (DEP)	0
371	A0213	Di-nonyl-phthalate (DNP)	0

	A	Analyte	AGTS
371	A0214	Di-iso-octyl-phthalate (DIOP)	0
371	A0224	Di-iso-hexylphthalate (DIHxP)	0
371	A0229	1,2-Benzene-di-carboxylic acid / Phthalic acid	0
371	A0323	Tetra-bromo-diphenyl-ether (TetraBDE)	0
371	A0325	Hexa-bromo-diphenyl-ether	0
371	A0326	Hepta-bromo-diphenyl-ether	0
371	A0327	Octa-bromo-diphenyl-ether	0
371	A0329	Deca-bromo-diphenyl-ether	0
371	A0332	Tris-(aziridinyl)-phosphinoxide (TEPA)	0
371	A0333	BDBPT	0
371	A0336	Bis (2,3-dibromopropyl) phosphate (BIS/BIS-BP)	0
371	A0420	2,4,5-Trimethylaniline	0
371	A0437	Disperse blue 26	0
371	A0439	Disperse blue 102	0
371	A0440	Disperse blue 106	0
371	A0443	Disperse orange 1	0
371	A0446	Disperse orange 149	0
371	A0450	Disperse yellow 1	0
371	A0452	Disperse yellow 9	0
371	A0453	Disperse yellow 23	0
371	A0454	Disperse yellow 39	0
371	A0455	Disperse yellow 49	0
371	A0456	Direct brown 95	0
371	A0460	Acid red 73	0
371	A0464	Solvent yellow 1	0
371	A0465	Solvent yellow 2	0
371	A0466	Solvent yellow 3	0
371	A0467	Disperse orange 11	0
371	A0503	Dioctyltin (DOT)	0
371	A0516	Monoethyltin (MET)	0
371	A0517	Monopropyltin (MPT)	0
371	A0618	Perfluorotridecanoic acid (PFTrA)	0
371	A0619	Perfluorotetradecanoic acid (PFTeA)	0
371	A0621	Perfluoroheptanesulfonic acid (PFHpS)	0
371	A0622	Perfluorodecanesulfonic acid (PFDS)	0

Table 3.2. (continued)

	A	Analyte	AGTS
371	A0628	1H,1H,2H,2H-Perfluorohexane-1-ol (4:2 FTOH)	0
371	A0630	1H,1H,2H,2H-Perfluoro-1-decanol (8:2 FTOH)	0
371	A0631	1H,1H,2H,2H-Perfluorododecan-1-ol (10:2 FTOH)	0
371	A0633	1H,1H,2H,2H-Perfluorodecylacrylate (8:2 FTA)	0
371	A0635	2H,2H-perfluorodecanoate (H2PFDA)	0
371	A0636	7H-dodecafluoroheptanoate (HPFHpA)	0
371	A0637	Perfluoro-3,7-dimethyloctanoate (PF-3,7-DMOA)	0
371	A0722	Pentachlorotoluene	0
371	A0727	2,4-Dichlorotoluene	0
371	A0730	3,4-Dichlorotoluene	0
371	A0815	Benzyl chloride	0
371	A1302	DTTB / Timiperone	0

	A	Analyte	AGTS
371	A1338	Hexachlorbenzene	0
371	A1343	Kelevan	0
371	A1402	5-Chloro-2-methyl-4-isothiazoline-3-one	0
371	A1405	Biocidic finish	0
371	A1501	Tri-o-cresyl phosphate	0
371	A1509	Tris(2-ethylhexyl)phosphate	0
371	A1645	2-Methoxyethylacetate	0
371	A1646	2-Methoxypropylacetate	0
371	A1719	Cyclopenta(c,d)pyrene	0
371	A1721	Dibenzo(a,l)pyrene	0
371	A1722	Dibenzo(a,i)pyrene	0
371	A1806	Tetramethylxylene diisocyanate (TMXDI)	0

In Table 3.2 the average AGTS for every class of compounds is reported. The most dangerous class are C11 (metals and metalloids), C05 (organotin compounds) and C13 (pesticides). The higher position of C05 in this ranking than in the previous one (Table 2.2) is due to the high dermal acute toxicity of organotins, on average, compared to the other classes.

Table 3.2. Ranking of class of analytes, based on the average Analyte Global Toxicity Score (AGTS, range in brackets) for clothing.

Class		Average AGTS (range)
C11	Metals and metalloids	144 (0-447)
C05	Organotin compounds	63 (0-439)
C13	Pesticides	57 (0-431)
C18	Diisocyanates	44 (0-84)
C08	Solvents	29 (0-416)
C04	Dyes	25 (0-292)
C17	PAHs - Polycyclic Aromatic Hydrocarbons	17 (0-54)
C16	VOCs - Volatile Organic Compounds	13 (0-319)
C10	Short-Chain Chlorinated Paraffins (SCCP)	6.3 (6.1-6.4)
C14	Biocidics	6.2 (0-18)
C01	Alkylphenols	6.0 (2.7-7.1)
C07	Chlorobenzenes and chlorotoluenes	5.9 (0-51)
C09	Phenols	5.3 (0-14)
C03	Brominated and chlorinated flame retardants	5.1 (0-41)
C15	Organic phosphor acetic acid esters	4.6 (0-17)
C02	Phthalates	3.4 (0-7.7)
C06	Poly- and per-fluorinated chemicals (PFAS)	1.5 (0-19)

3.2. Focusing on clothing data

Data of clothing required a strong data elaboration. A carefull selection was made from the original dataset.

- Only useful chemical concentration data was selected: pH, rating, absorbency, phenolic yellowing and qualitative data were discared;
- Some concentration data was expressed as "not detected", ma no LOD was reported; some other data was reported as "detected" with no specific value. All data not associated to a specific numerical value was rejected;
- Only values with the same unit of measure can be compared. Since almost all values were expressed in mg/Kg, concentration data in *weight*/*weight* was retained; data of release, usually expressed as *weight*/*time*, and data of concentration on surface (*weight*/*area*) was discared;
- Overlays of analytes were carefully checked. Sometimes both concentration data of groups of compounds and single components of the group was reported for the same sample in the original dataset; in these cases only single values were retained. When the same analyte was analysed using different methods, only data produced using the most generic method was retained, since it could be more appropriately compared to concentration data of other analytes.

In the revised dataset, 863420 concentration values were present, relating to 57222 samples. Data covered a period between 2010 to the first months of 2017; most of which was collected from 2013 to 2016 (Figure 3.1).

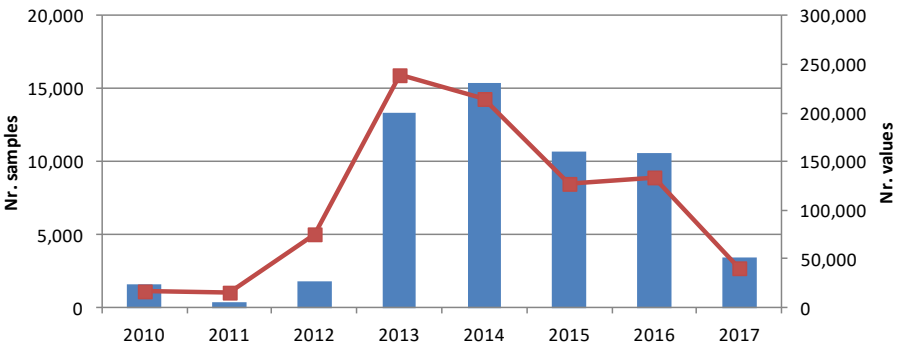


Figure 3.1. Distribution of data and analysed samples, over time.

Not all of the 435 compounds were analysed in all samples; indeed, almost 90% of samples are characterised by less than 25 analytes, with an average of 10 concentration values per sample. This variability should be taken into consideration when compairing results. 84% of collected data is represented by metals and metalloids (C11), phthalates (C02) and dyes (C04) (Figure 3.3).

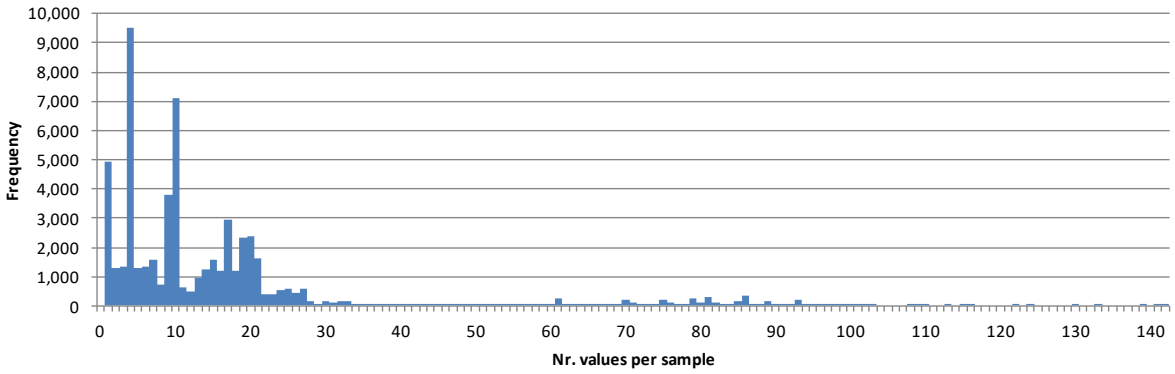


Figure 3.2. Frequency of number of analysed compounds per sample.

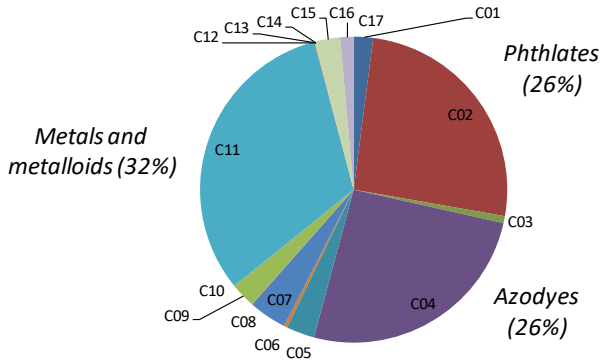


Figure 3.3. Distribution of data among classes of compounds.

Accordigly within the previous wastewater evaluation[8], most concentration data in clothing is below the limit of detection, with only 2.5% above LOD. Figure 3.4 and Figure 3.5 show the percentage of detected analytes per class and per year respectively. The classes with the relative highest quantity of detected

[8] "Environmental impacts research and smart monitoring strategy development focused on the DETOX Programme", by E. Gregoris, M. Roman, A. Gambaro and C. Barbante, DAIS, Ca' Foscari University of Venice. Technical report, 2016. Pag. 16.

analytes are solvents (C08), short-chain chlorinated paraffins (C10) and organic phosphor acetic acid esters (C15). No specific chronological trend is identificable.

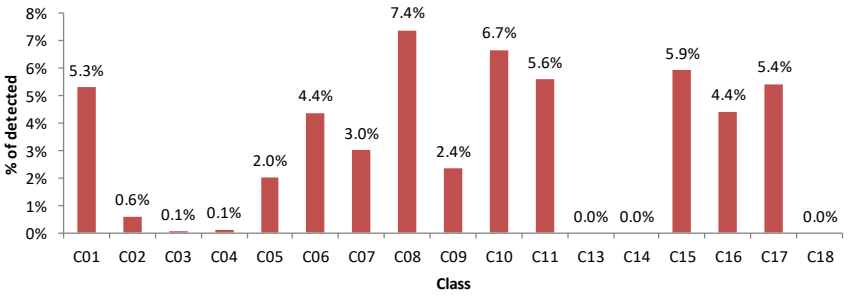


Figure 3.4. Percentage of detected analytes per class.

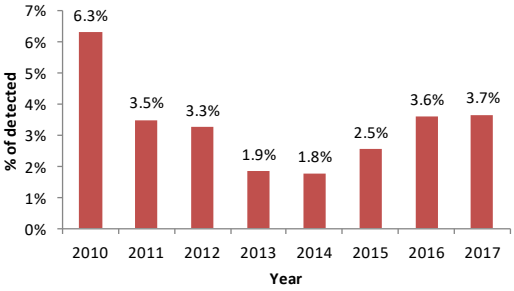


Figure 3.5. Percentage of detected analytes per year.

3.3. Clothing evaluation

A sample global toxicity score (SGTS) was calculated, applying the same equation used for FGTS (Paragraph 3.3). For all analytes that have a concentration below the limit of detection (LOD), the half of LOD was considered. All possible overlaps were taken into consideration, in order to not have overestimation of the scores.

Based on the SGTS profile, samples were classified into five impact categories, whose limits are listed in Table 2.3.

Table 3.3. Impact categories for wastewater samples, based on SGTS values.

Impact	SGTS
Minimum impact	From 0 to 0.1
Weak impact	From 0.1 to 1
Medium impact	From 1 to 10
Strong impact	From 10 to 100
Extreme impact	From 100 to 1000

All SGTS values of clothing samples are reported in the annex "Toxicity Score CLOTHING". Every sample is idenficable by a sample code, which was built on the base of the sample ID or style number and on the specific analysed component (or component code), so that each data set could be identified by a unique code. In the annex data is filterable based on several parametes, such as level of impact or year of the measure. The last column on the right contains links for the specific data files - located in "Data Clothing" folder - containing information about the corresponding sample. In these worksheets, the last column on the right give the percentage of contribution of each data to the total of the selected data; this information could be useful after filtering a specific sample. Figure 3.6 shows the SGTS profile, in logaritmic scale: 98% of samples are classified as minimum impact; 44 samples are classified as extreme impact. Given the huge

amount of data, an in-depth assessment could be made after a classification of samples in categories (such as clothes, accessories, shoes, etc.) or type of material (leather, plastic materials, metal accessories). Such a study could clarify also the high average SGTS observed in 2012 (Figure 3.7), which cannot find an explanation with the available information.

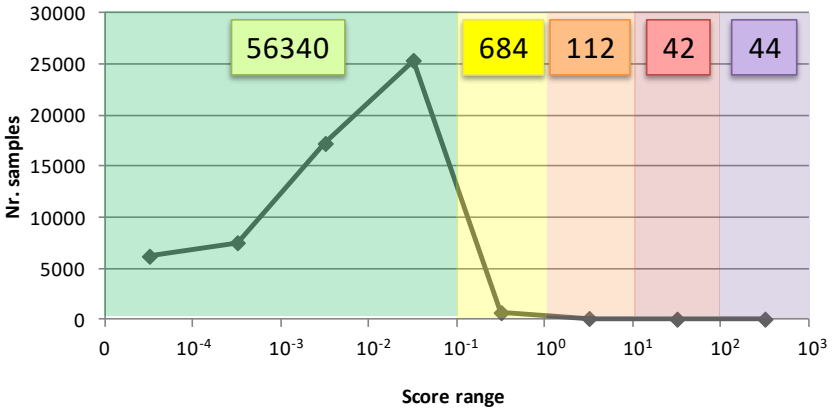
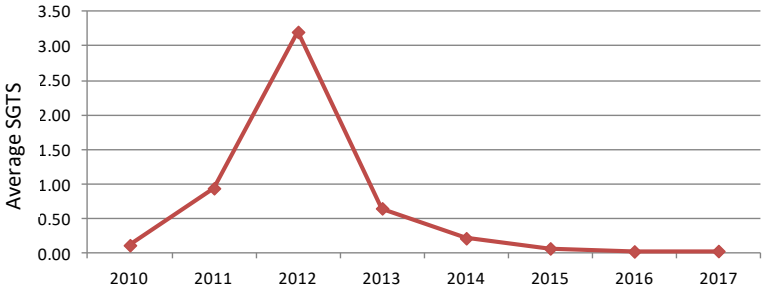


Figure 3.6. SGTS profile.

Figure 3.7. Chronological trend of SGTS



The first samples of the ranking are characterised by a low amount of concentration values (from 1 to 6). Samples were analysed only by metals and almost all datasets show a very high concentration of nickel, leading to the hypotesis that they could be metal application or accessories.

Table 3.4. Concentration data of the first samples in the clothing ranking.

Rank	Sample code	Sample ID	Sample descript	Year	Score	Concentration
#1	81889-07	81889-07	6GPGW11L2, col. 700, Supplier: CB	2012	1000	Nickel 95.2%
#2	81898-06	81898-06	6GPGW11L2, col. 912, supplier: CB	2012	840	Nickel 80.0%
#3	151744-08	151744-08	Art. D2 Benetton, Season: FW/13	2013	774	Nickel 73.7%
#4	151744-07	151744-07	Art. D2 Benetton, Season: FW/13	2013	769	Nickel 73.2%
#5	226005-01	226005-01	IPAM srl-TRIM - WARM APPLICATION - METAL , col. 4042520000001, Season: SS/155, Supplier: IPAM srl	2014	756	Nickel 72.0% Lead 0.0024% Cadmium ND Mercury ND Arsenic ND Tin ND
#6	226052-03-001	226052-03	Bott. Corna & Fratus-TRIM - METAL, col. 4009250002921, Season: SS/15, Supplier: Bott. Corna & Fratus	2014	735	Lead 49% Arsenic 0.0026 % Tin 0.45% Cadmium ND Mercury ND
#7	147548-02	147548-02	6GYVW6027, col. 700, Season: FW/13	2013	714	Nickel 68.0%
#7	147548-03	147548-03	6GYVW6027, col. 700, Season: FW/13	2013	714	Nickel 68.0%
#9	81889-06	81889-06	6GPGW11L2, col. 700, Supplier: CB	2012	662	Nickel 63.0%
#10	151693-09	151693-09	Art. B2 Benetton, Season: FW/13	2013	653	Nickel 62.2%

CONCLUSIONS

In this work a previously optimised method for the evaluation of the chemical-toxicological impact of manufacturing facilities was used and re-adapted for the evaluation of facilties and clothing. Two different rankings of analytes were built, attributing different importance to toxicity of compounds, based on the type of samples. The major results can be summarise as follows:

- For wastewater, 158 studied were conducted, collecting data of incoming water, untreated wastewater and treated wastewater. The most critical facilities were investigated in 2013 and 2014. Two facilities studied in 2016 show a medium impact: F132 (ITA) and F136 (HRV). The compounds that most contribute to the high score with these facilities are cyanide and heavy metals.
- For clothing, 57222 samples were analysed; 44 of them show extreme impact; the first samples of the ranking show very high levels of nickel. Further information are needed in order to conduct a better comparison among data.

Given the huge amount of data, results are reported in electronic annexes, in order to give a filtrable and interactive support. Globally, the following files are provided as annexes to this report:

- ✓ "Toxicity information": includes the criteria for the classification in categories of hazards and the converted values for levels of toxicity (pdf document);
- ✓ "Toxicity score WASTEWATER": includes all the global toxicity scores (FGTS) calculated for the manufacturing facilities (excel document);
- ✓ "Data wastewater" folder - including "Wastewater data" (excel document). It contains all concentration data collected for wastewater;
- ✓ "Toxicity score CLOTHING": includes all the global toxicity scores (SGTS) calculated for clothing samples (excel document);
- ✓ "Data Clothing folder" - including twenty excel documents which contain all concentration data collected for clothing:
  - → "CH1 data" and "CH2 data"; built from the original file "Analisi_CH_2014_2017";
  - → "CRO2010 data", "CRO2011 data", "CRO2012 data", "CRO2013 data", "CRO2014 data", "CRO2015 data", "CRO2016 data" and "CRO2017 data", built from the original file "Benetton_Chemical_Result_Overview_2010-2017_YTD";
  - → "DPC1 data", built from the original file "dati prodotto clean 1";
  - → "DPC2 data", built from the original file "dati prodotto clean 2";
  - → "HK1 data", "HK2 data", "HK3 data" and "HK4 data", built from the original file "HK_Analisi_2013_2017";
  - → "TUN1 data", "TUN2 data", "TUN3 data" and "TUN4 data"; built from the original file "TUN_Analisi_2013_2017".