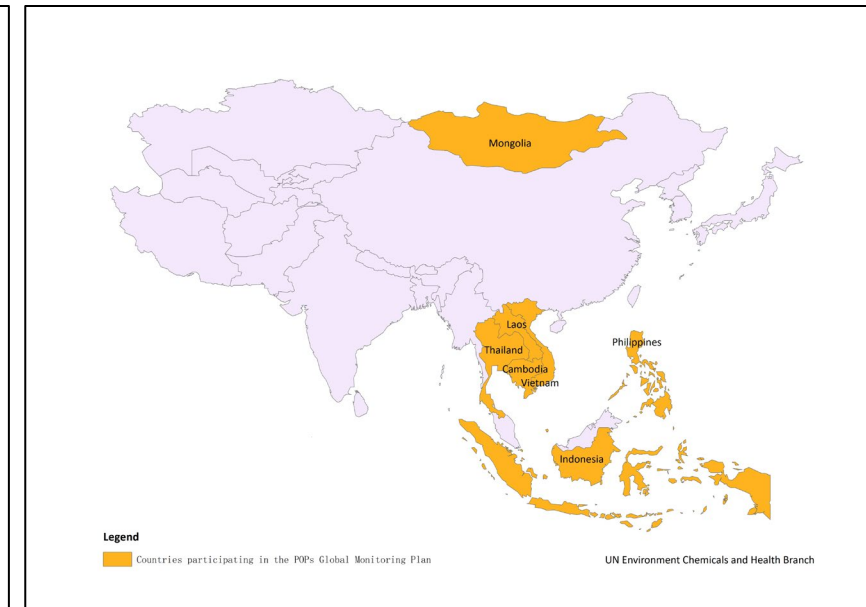
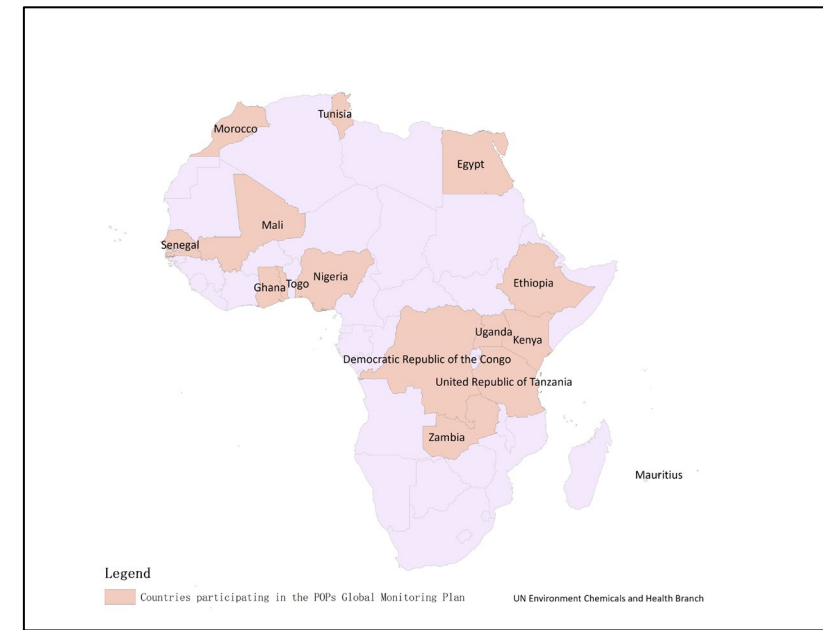
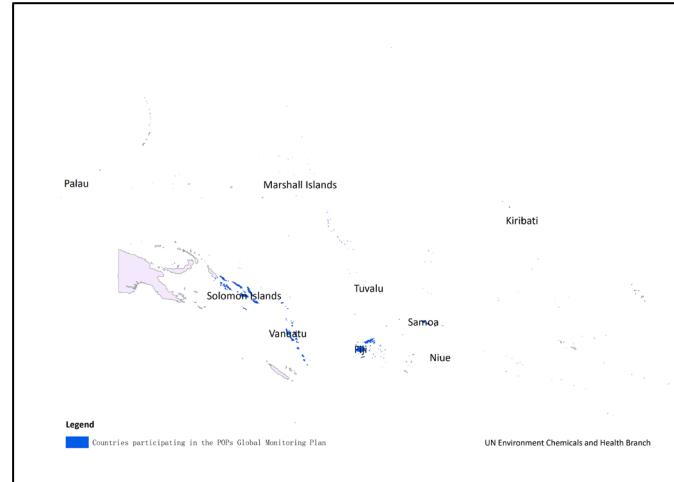


PFAS and dl-POPs in Air by Expert Laboratory



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E-mail: heidlore.fiedler@oru.se

UNEP guidance documents and participants



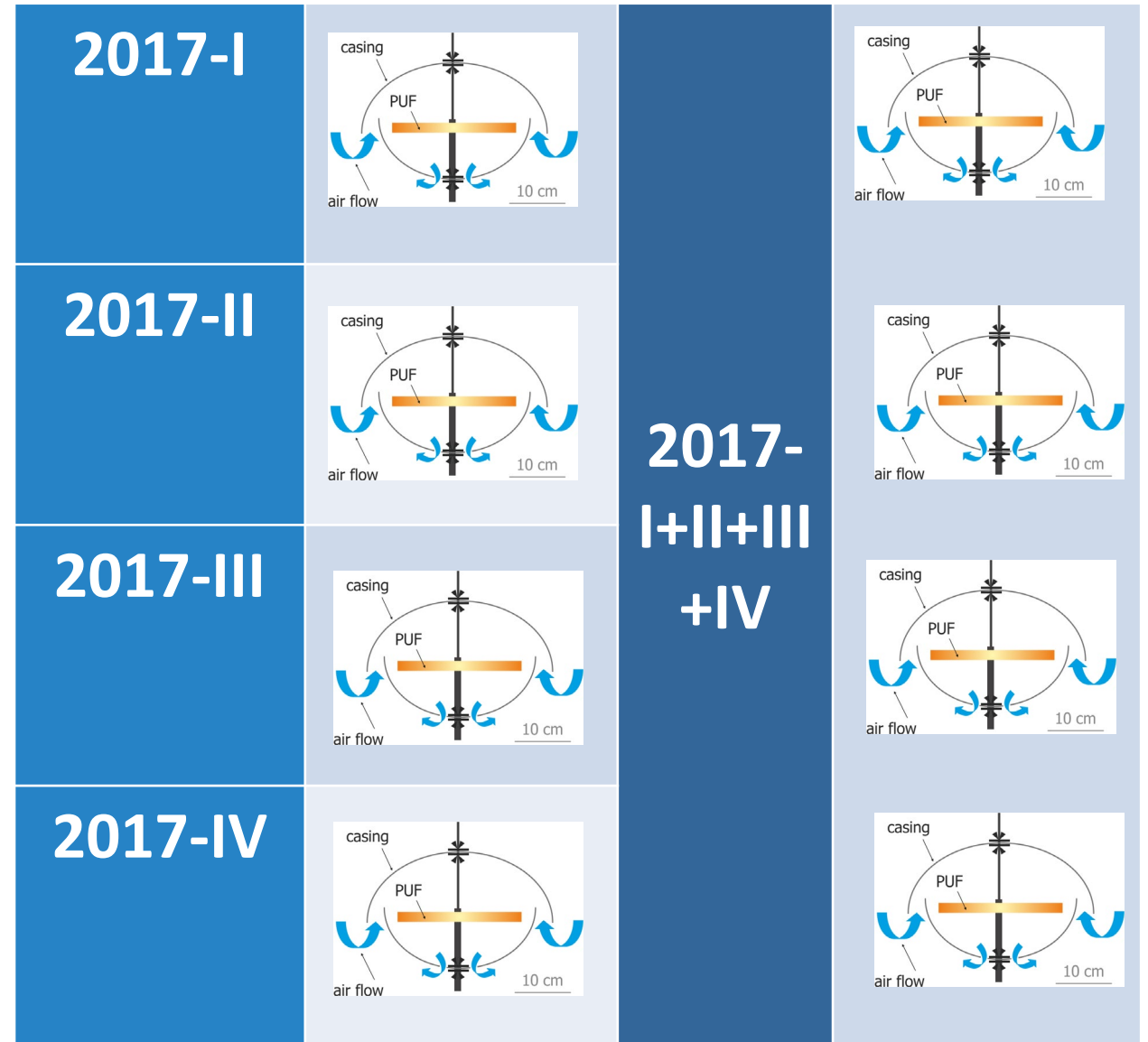
Samples - Reporting

All samples/results are defined as

- ISO-3 code for country
- Sampling Year – YYYY
- Season (I, II, III or IV)

- Each season is defined as 90 days or 3 months

- Results are normalized to 1 PUF and 3 months exposure



Definitions – World Bank indicators

Income according to World Bank classification (WBC)

WBC class	GNI per capita, Atlas method (current US\$)
High income	> 12,375
Upper middle income	3,996-12,375
Lower middle income	1,026-3,995
Low income	<= 1,025

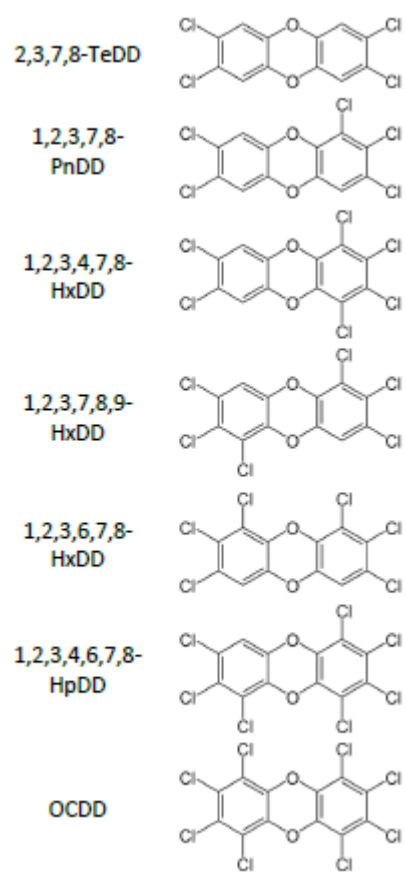
Population density based on World Bank statistics

PD_Code	Range: Inhabitants <i>per</i> km ²
A	<24.9999
B	>25-<99.99
C	>100-<499.9
D	>500-<999.99
E	>1,000-<10,000
F	>10,000

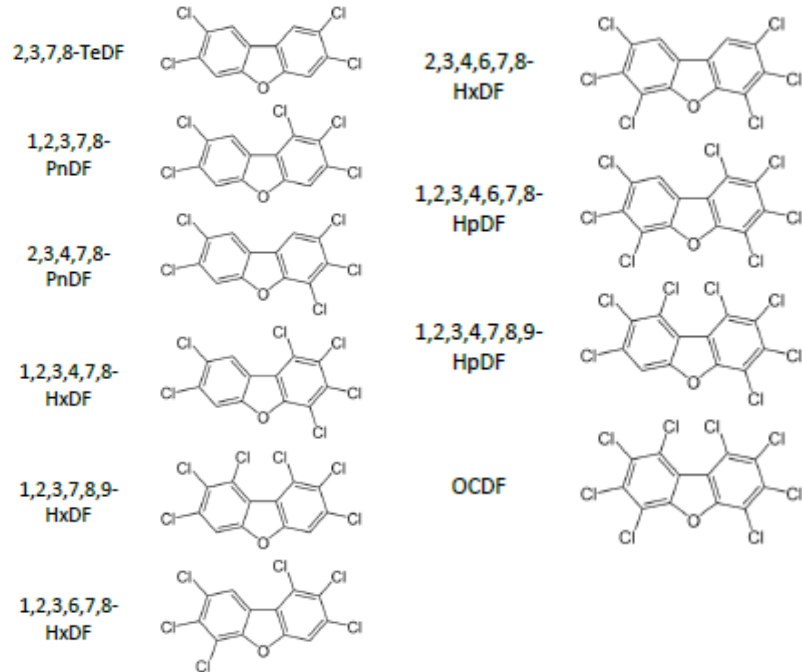
Dioxin-like (dl) POPs with WHO₂₀₀₅-TEFs

PCDD/PCDF (as TEQ DF)

PCDD

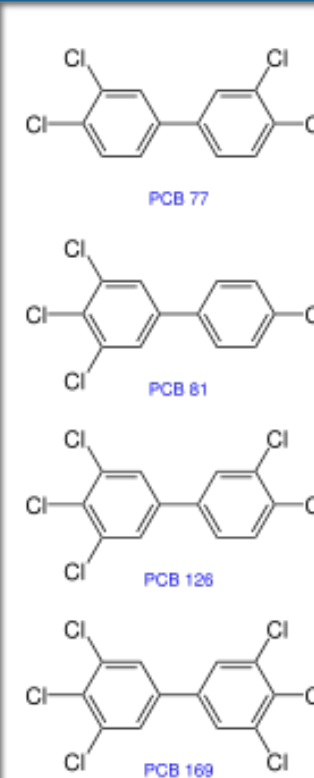


PCDF

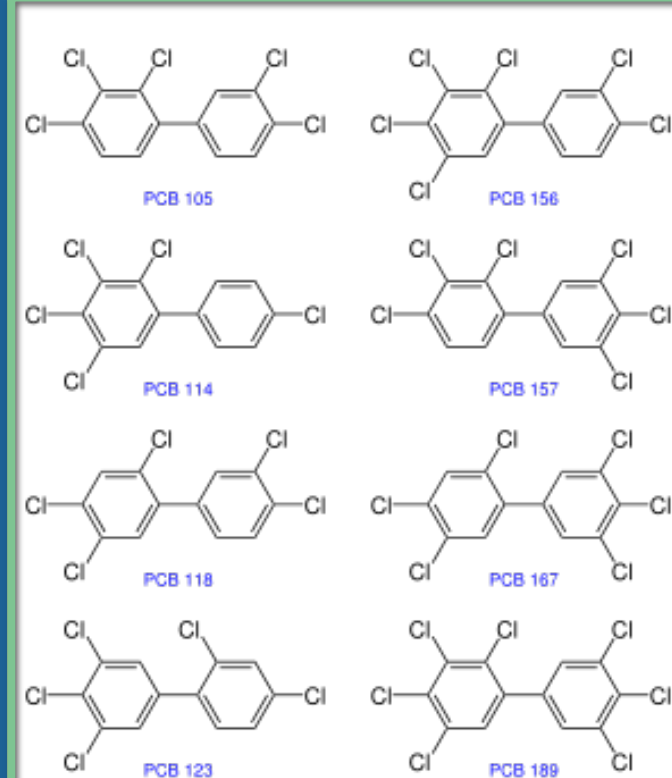


Dioxin-like PCB (as TEQ PCB)

Non-ortho (noPCB)



mono-ortho PCB (moPCB)



Overview number of samples dl-POPs - GMP1+GMP2

	Africa (N=94)	Asia (N=28)	GRULAC (N=79)	PAC (N=26)	Overall (N=227)
Region					
Africa	94 (100%)	0 (0%)	0 (0%)	0 (0%)	94 (41.4%)
Asia	0 (0%)	28 (100%)	0 (0%)	0 (0%)	28 (12.3%)
GRULAC	0 (0%)	0 (0%)	79 (100%)	0 (0%)	79 (34.8%)
PAC	0 (0%)	0 (0%)	0 (0%)	26 (100%)	26 (11.5%)
GMP					
GMP1	10 (10.6%)	0 (0%)	27 (34.2%)	8 (30.8%)	45 (19.8%)
GMP2	84 (89.4%)	28 (100%)	52 (65.8%)	18 (69.2%)	182 (80.2%)

Status:
2020-10-01

PAS/PUF Results – dl-POPs

A.2 GMP 2 - Across All Projects

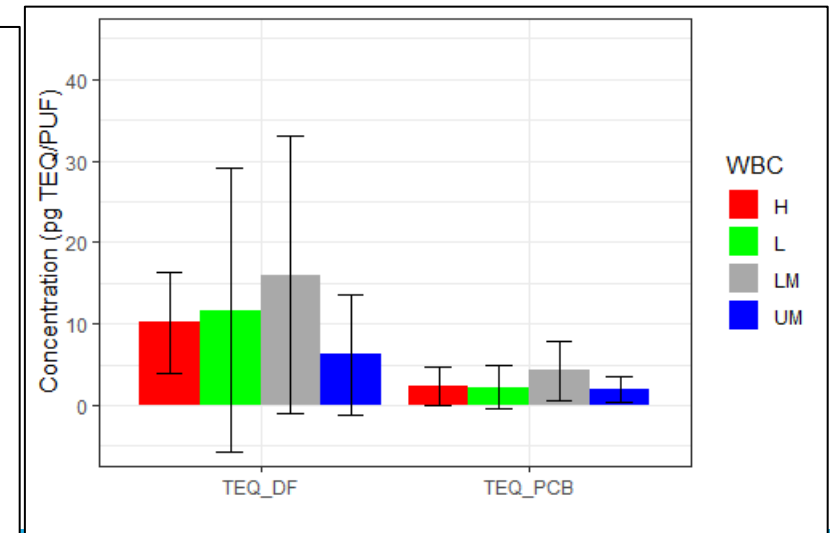
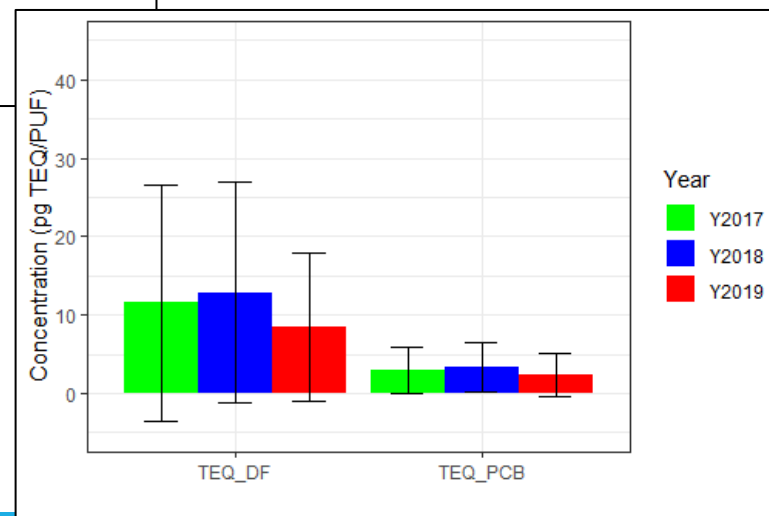
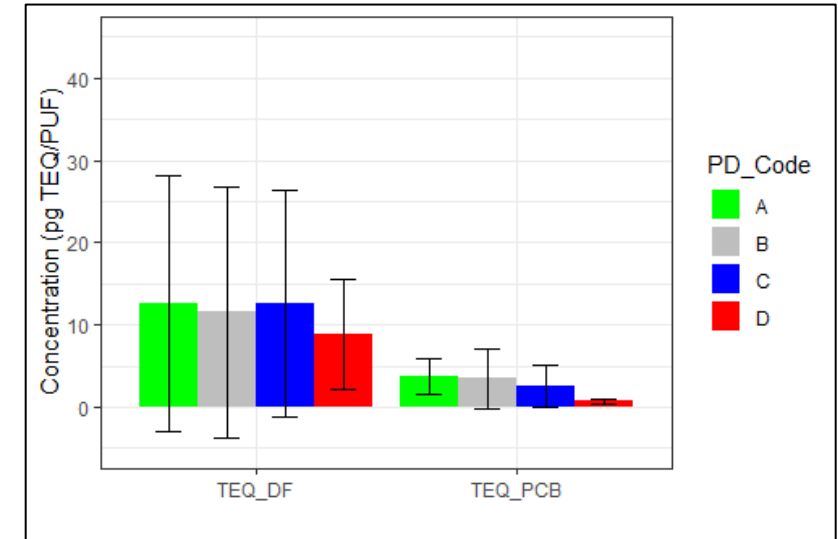
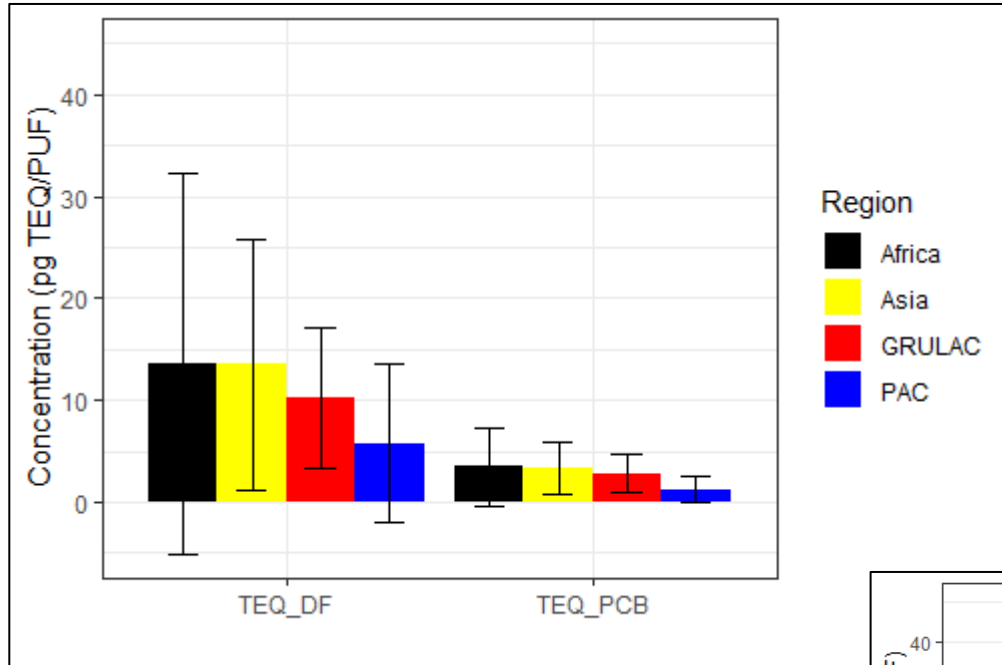
Number/classification PAS/PUFs GMP2 for dl-POPs

	Africa (N=83)	Asia (N=28)	GRULAC (N=52)	PAC (N=19)	Overall (N=182)
Region					
Africa	83 (100%)	0 (0%)	0 (0%)	0 (0%)	83 (45.6%)
Asia	0 (0%)	28 (100%)	0 (0%)	0 (0%)	28 (15.4%)
GRULAC	0 (0%)	0 (0%)	52 (100%)	0 (0%)	52 (28.6%)
PAC	0 (0%)	0 (0%)	0 (0%)	19 (100%)	19 (10.4%)
YYYY					
Y2017	58 (69.9%)	9 (32.1%)	26 (50.0%)	11 (57.9%)	104 (57.1%)
Y2018	21 (25.3%)	12 (42.9%)	26 (50.0%)	7 (36.8%)	66 (36.3%)
Y2019	4 (4.8%)	7 (25.0%)	0 (0%)	1 (5.3%)	12 (6.6%)
Sample					
a	27 (32.5%)	11 (39.3%)	20 (38.5%)	12 (63.2%)	70 (38.5%)
q	56 (67.5%)	17 (60.7%)	32 (61.5%)	7 (36.8%)	112 (61.5%)

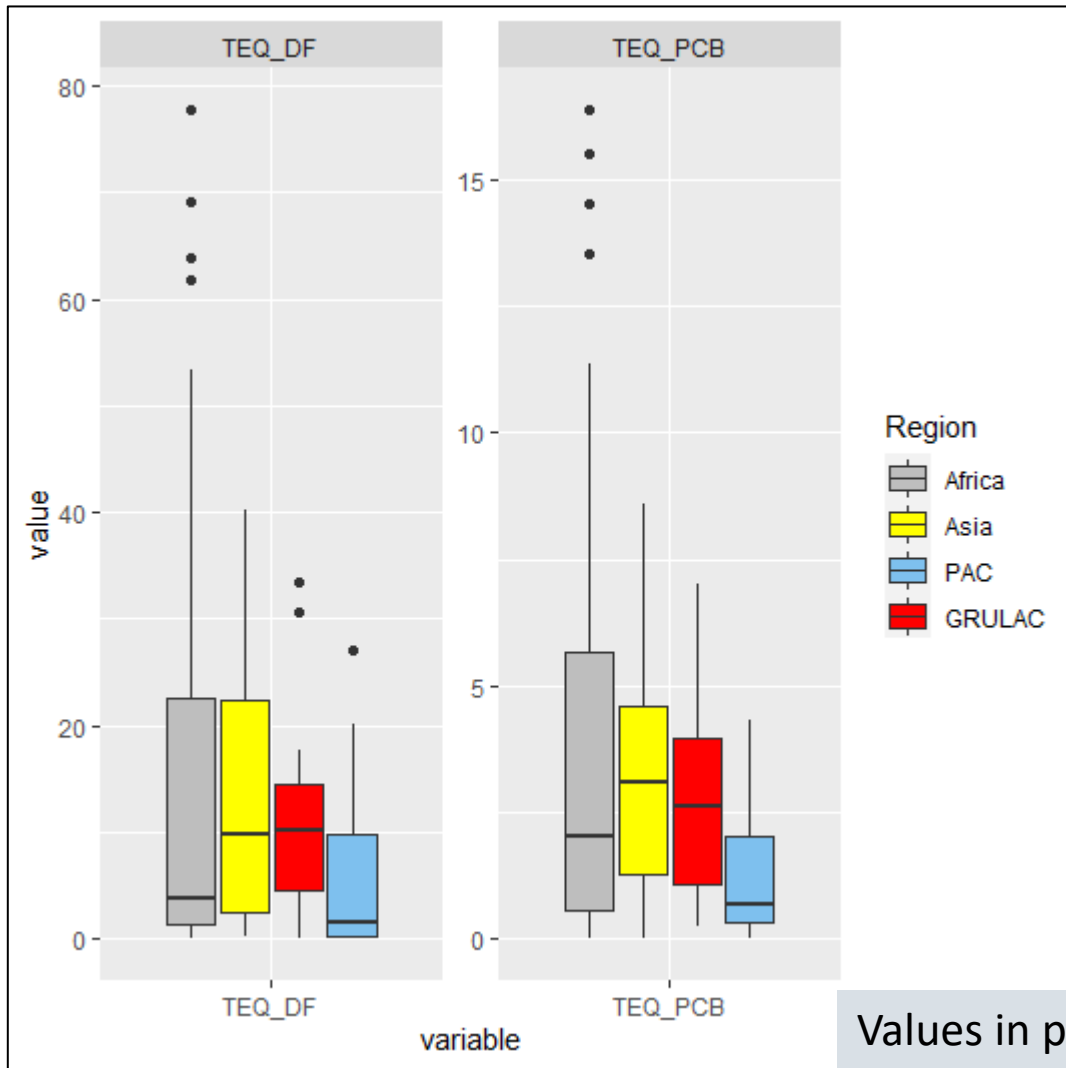
Summary results PAS/PUFs GMP2 for dl-POPs

	Africa (N=83)	Asia (N=28)	GRULAC (N=52)	PAC (N=19)	Overall (N=182)
DF (pg TEQ/PUF)					
Mean (SD)	13.6 (18.7)	13.5 (12.3)	10.2 (6.92)	5.75 (7.76)	11.8 (14.4)
Median [Min, Max]	3.77 [0.0552, 77.7]	9.80 [0.162, 40.3]	10.2 [0.141, 33.5]	1.49 [0.000495, 27.0]	6.59 [0.000495, 77.7]
PCB (pg TEQ/PUF)					
Mean (SD)	3.47 (3.82)	3.32 (2.51)	2.79 (1.87)	1.22 (1.26)	3.02 (3.03)
Median [Min, Max]	2.03 [0.000374, 16.4]	3.10 [0.00305, 8.57]	2.60 [0.253, 7.01]	0.675 [0.00234, 4.32]	2.25 [0.000374, 16.4]

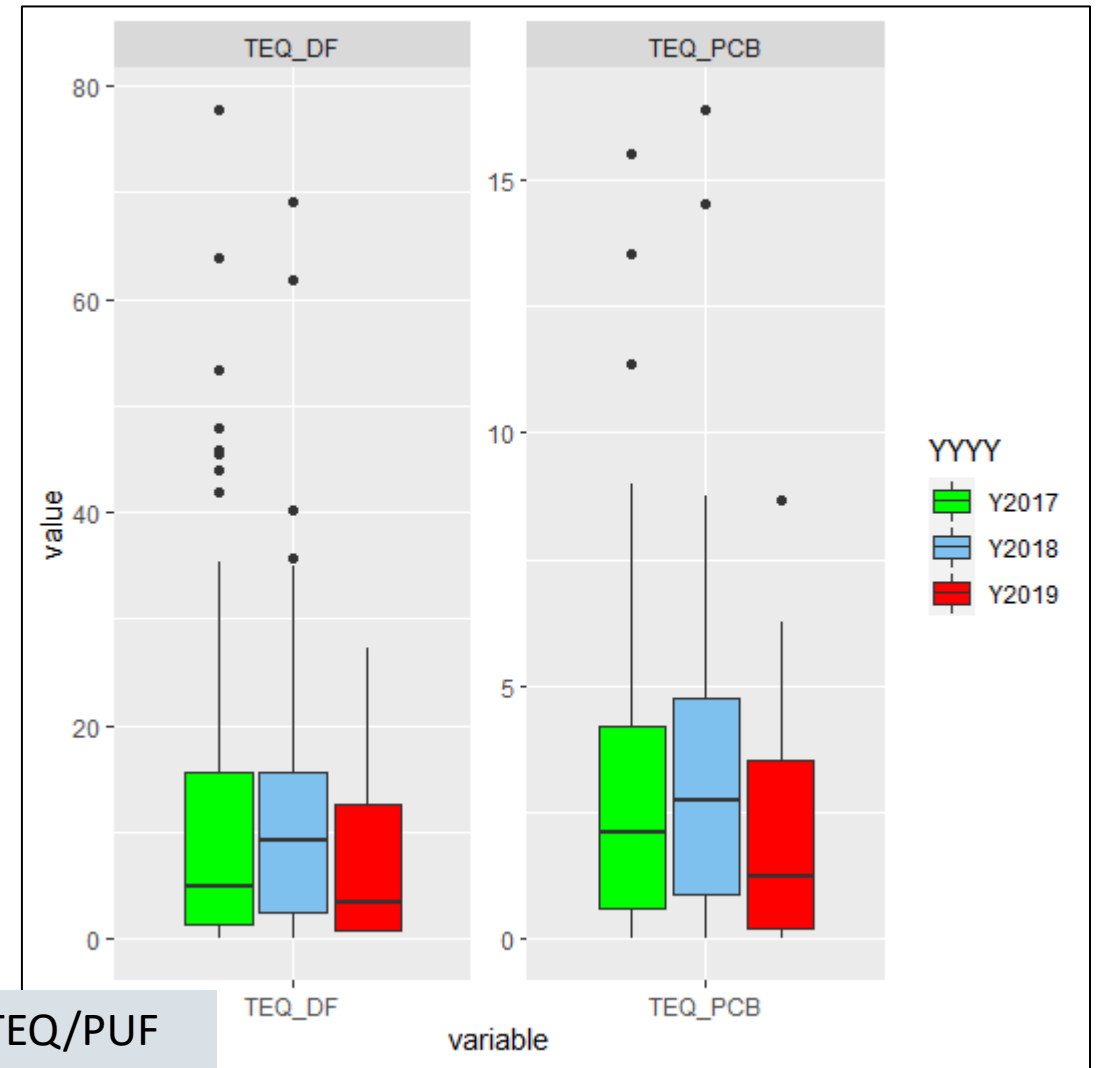
Mean values and SD (standard deviation) - GMP2



Regions

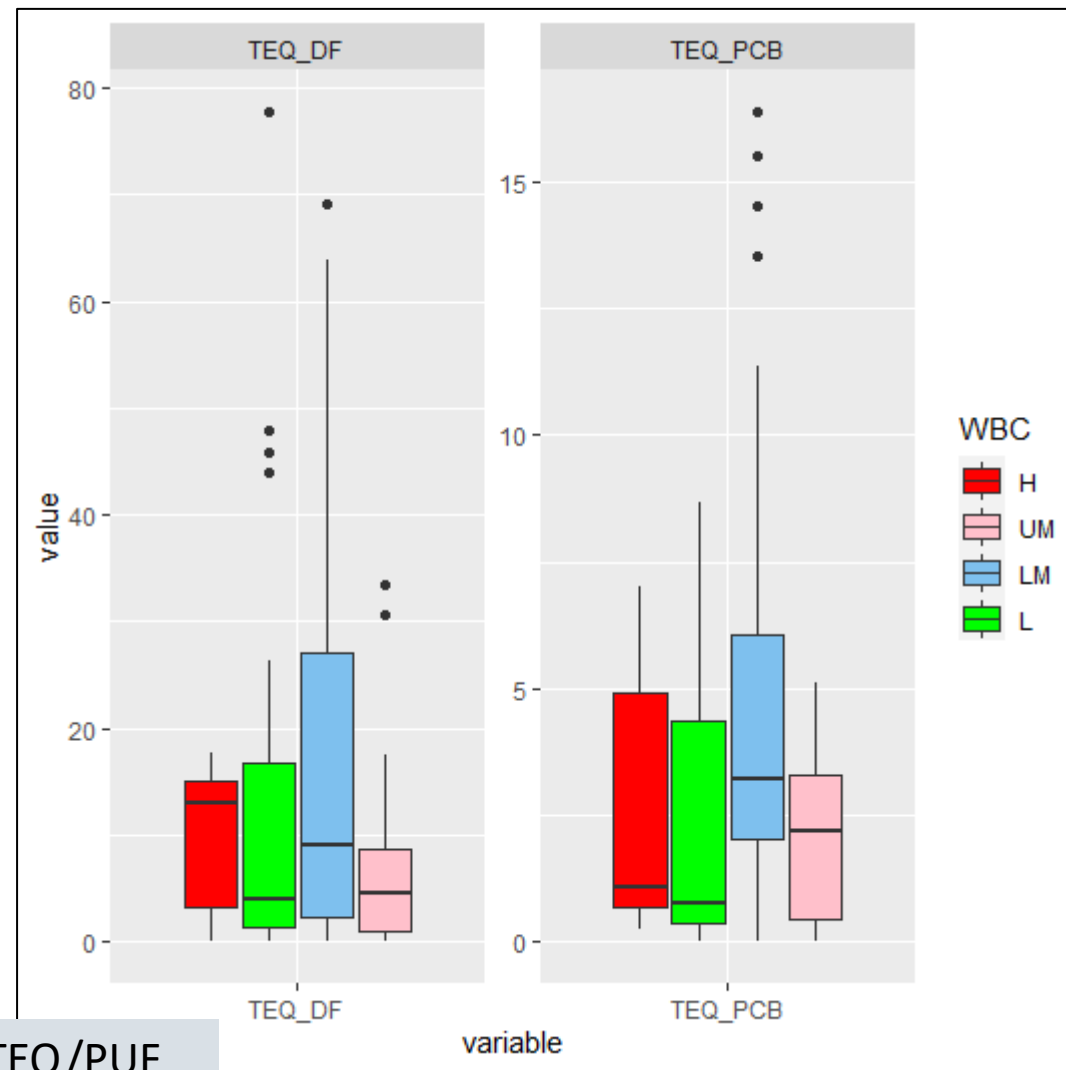
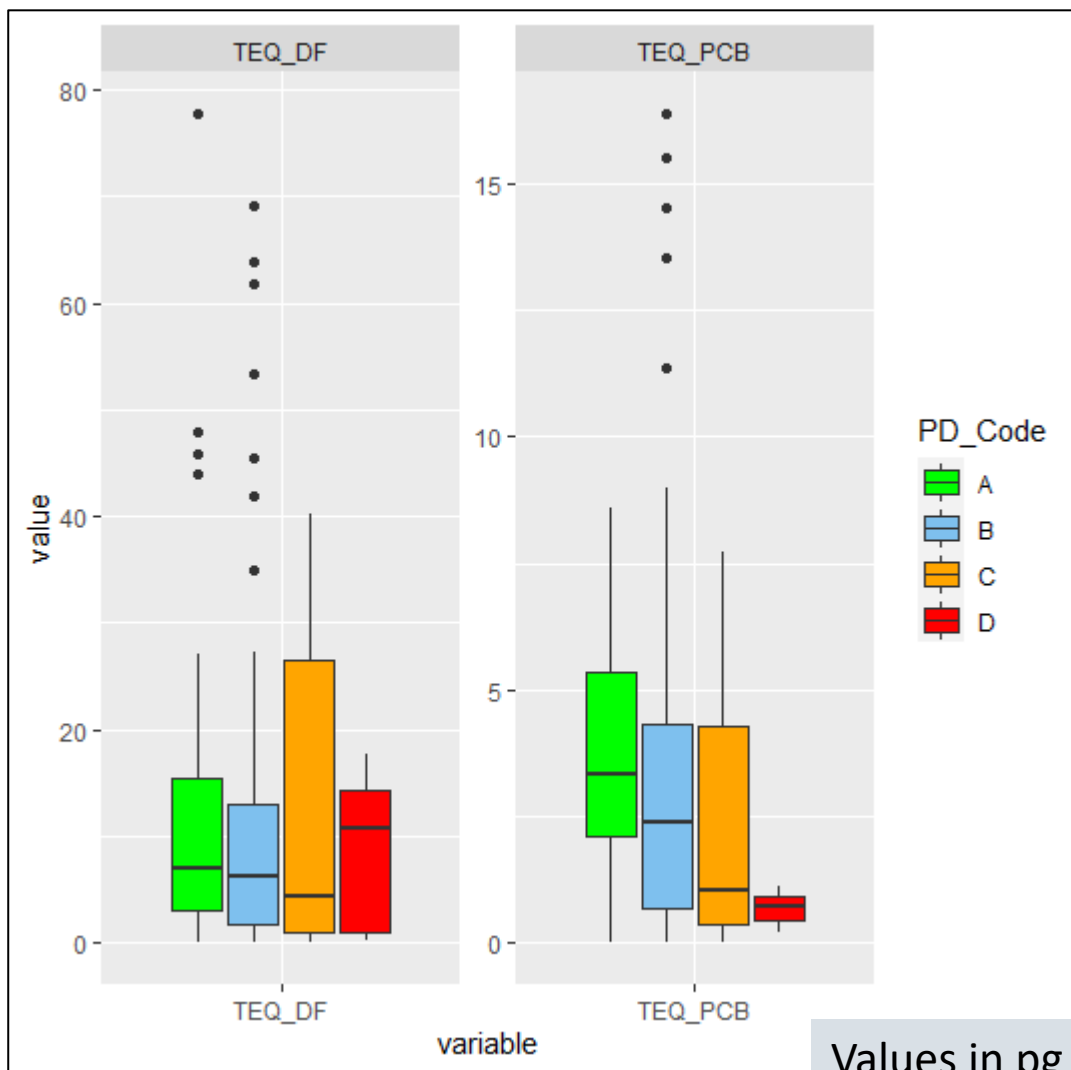


Sampling year



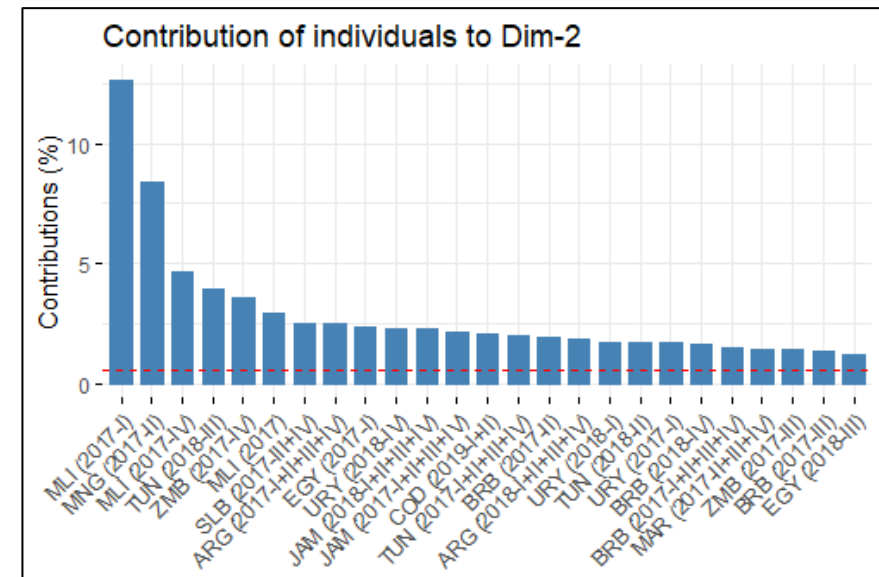
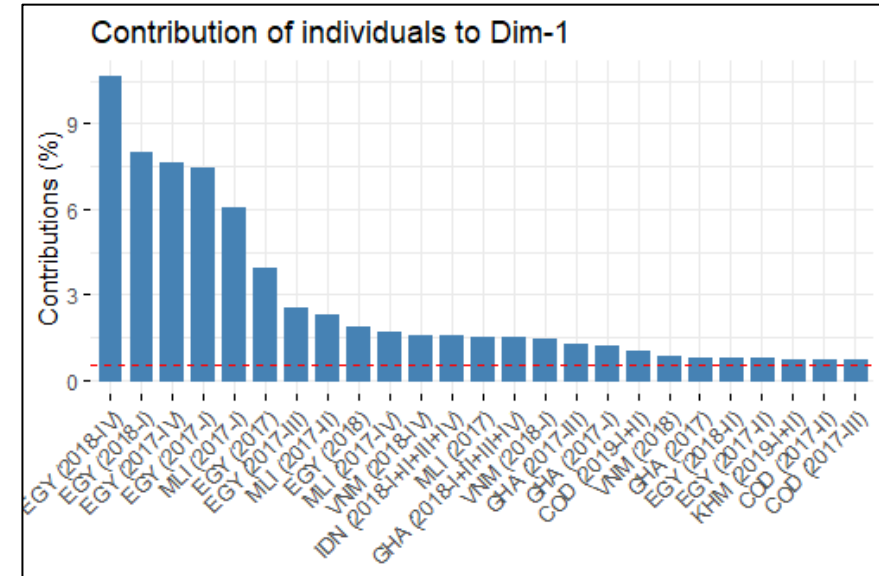
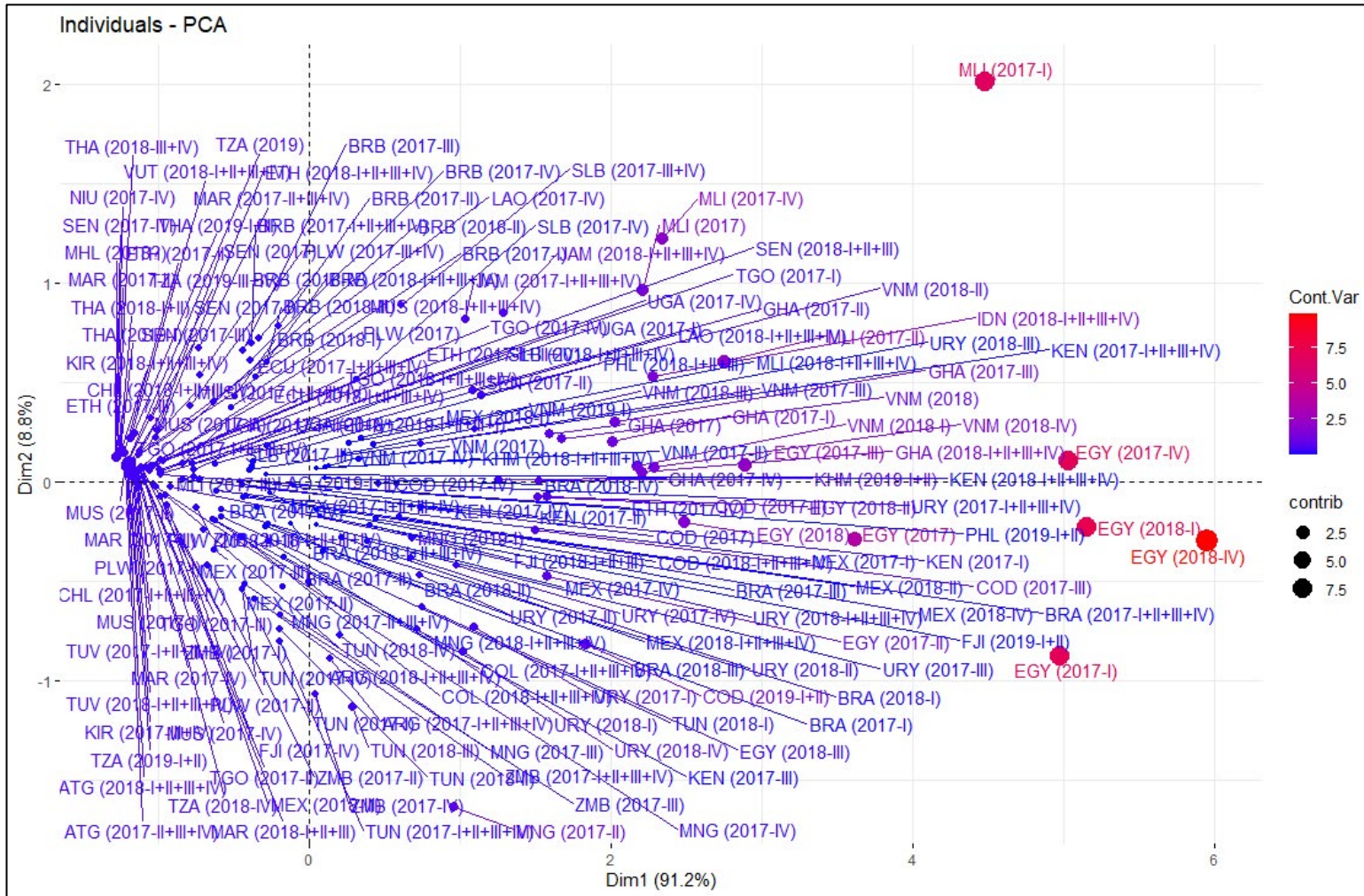
Population density

Income

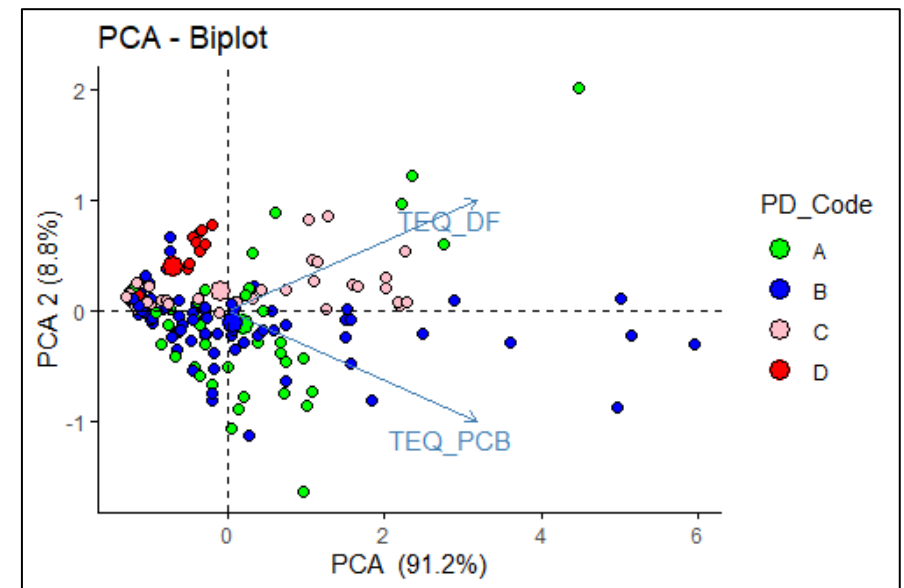
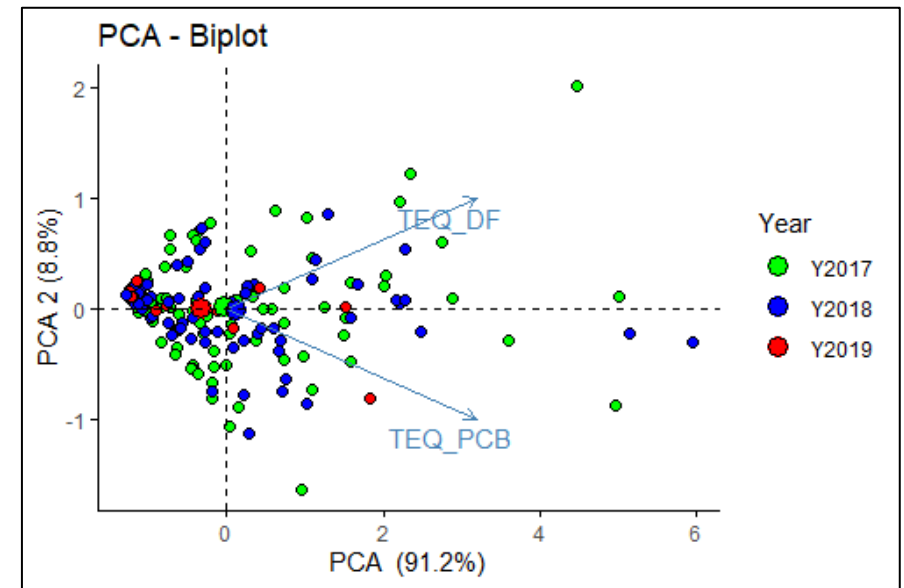
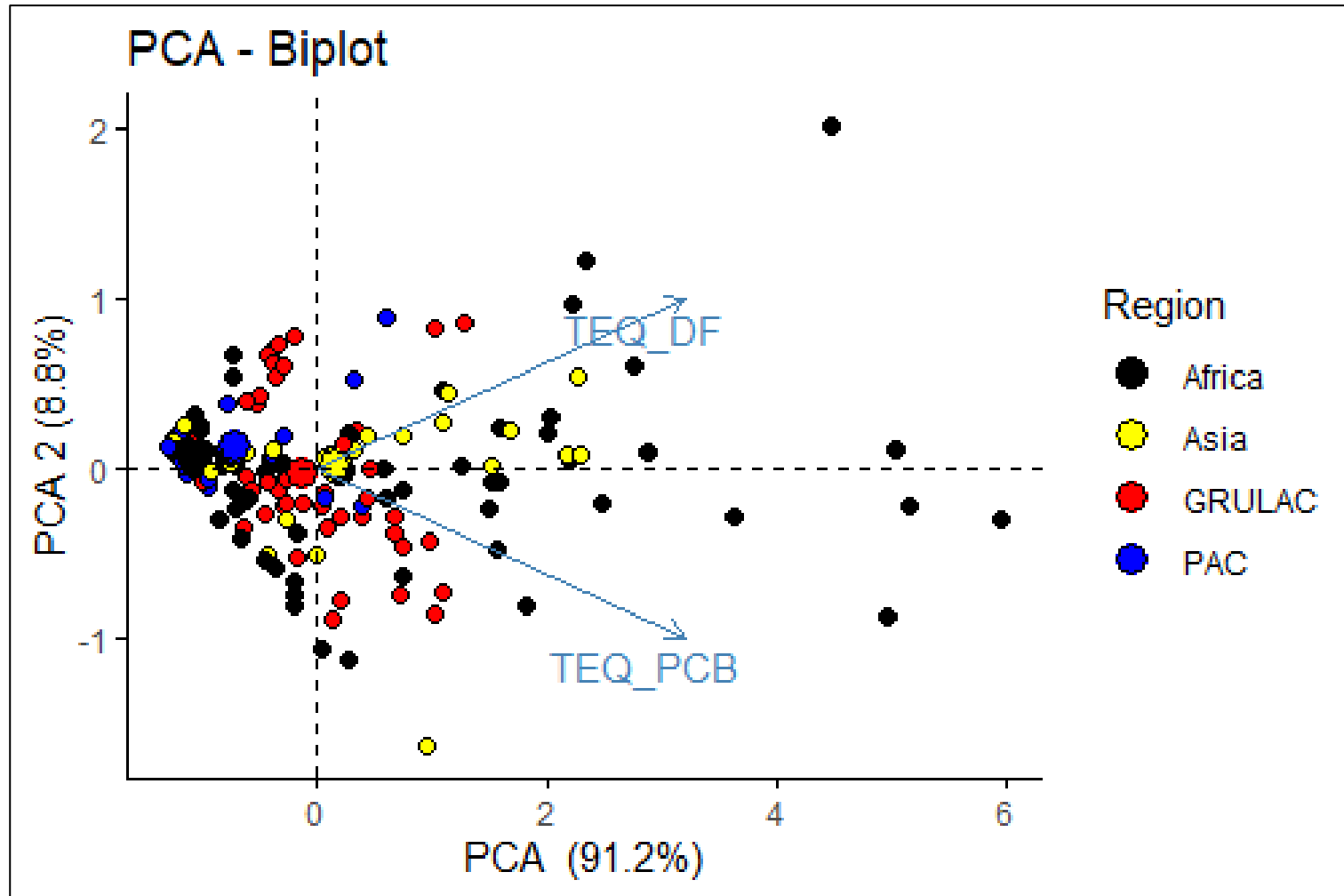


Values in pg WHO₂₀₀₅-TEQ/PUF

PCA, variance GMP2 dl-POPs



PCA dl-POPs GMP2



dl-POPs Results

A.5 PAC Region

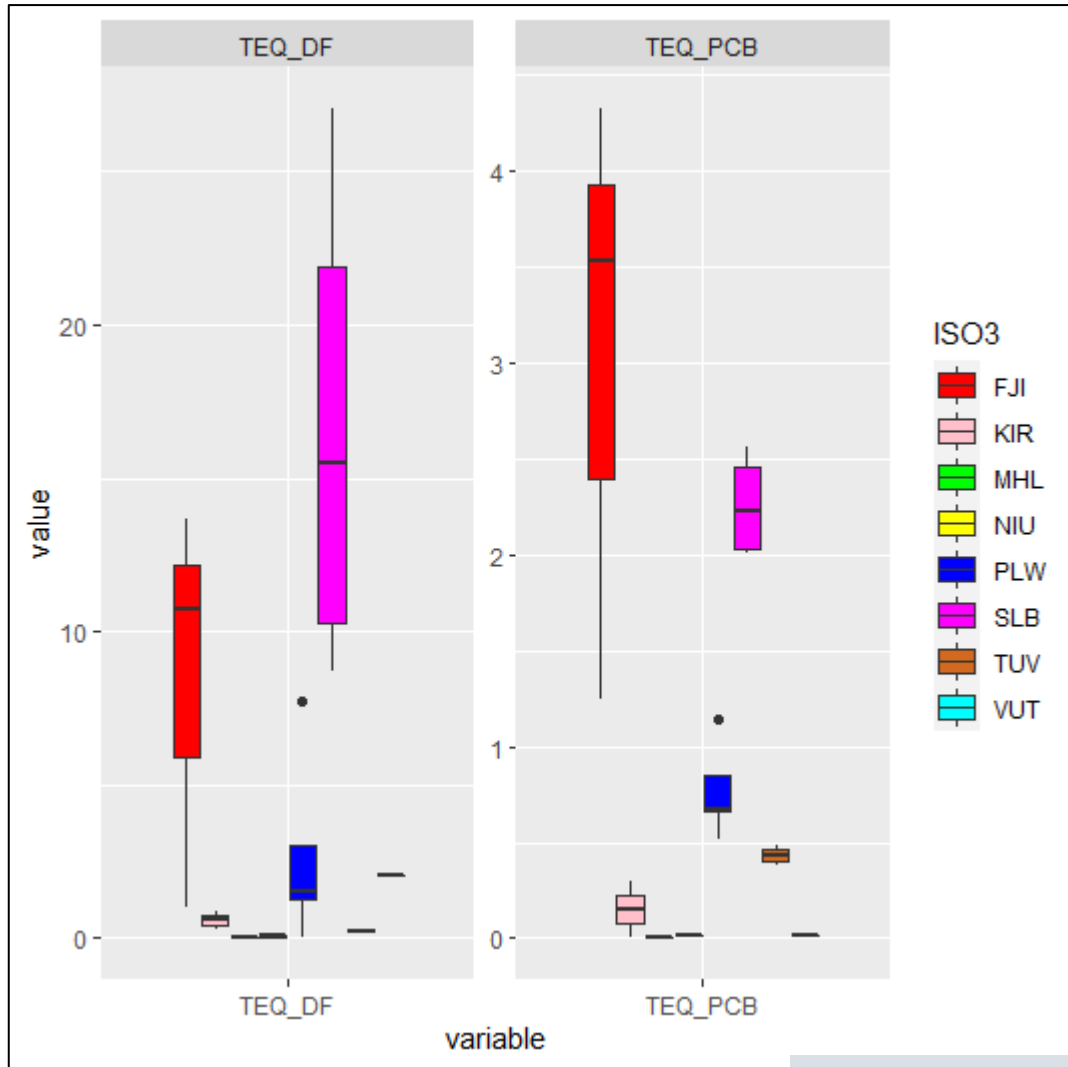
Country name	ISO-3	Project Region	WBC 2017	WBC 2018	PD 2017	PD 2018
Fiji	FJI	PAC	UM	UM	B	B
Kiribati	KIR	PAC	LM	LM	C	C
Marshall Islands	MHL	PAC	UM	UM	C	C
Niue	NIU	PAC	UM	UM	A	A
Palau	PLW	PAC	H	H	B	B
Samoa	WSM	PAC	UM	UM	B	B
Solomon Islands	SLB	PAC	LM	LM	A	A
Tuvalu	TUV	PAC	UM	UM	C	C
Vanuatu	VUT	PAC	LM	LM	A	A

Number of samples and results

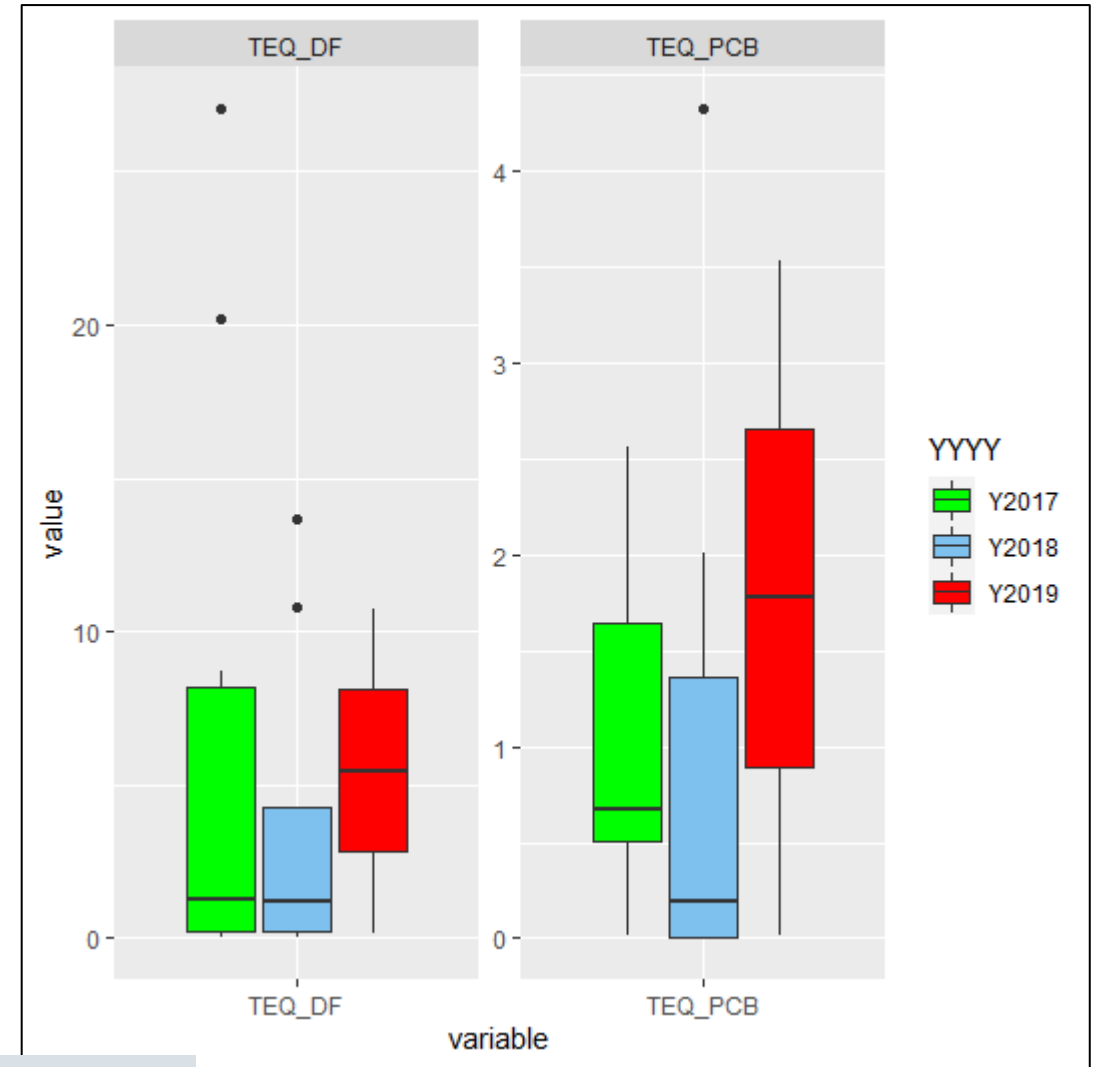
	FJI (N=3)	KIR (N=2)	MHL (N=1)	NIU (N=3)	PLW (N=5)	SLB (N=4)	TUV (N=2)	VUT (N=1)	Overall (N=21)
YYYY									
Y2017	1 (33.3%)	1 (50.0%)	0 (0%)	1 (33.3%)	4 (80.0%)	3 (75.0%)	1 (50.0%)	0 (0%)	11 (52.4%)
Y2018	1 (33.3%)	1 (50.0%)	1 (100%)	1 (33.3%)	1 (20.0%)	1 (25.0%)	1 (50.0%)	1 (100%)	8 (38.1%)
Y2019	1 (33.3%)	0 (0%)	0 (0%)	1 (33.3%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	2 (9.5%)
WBC									
LM	0 (0%)	2 (100%)	0 (0%)	0 (0%)	0 (0%)	4 (100%)	0 (0%)	1 (100%)	7 (33.3%)
UM	3 (100%)	0 (0%)	1 (100%)	3 (100%)	0 (0%)	0 (0%)	2 (100%)	0 (0%)	9 (42.9%)
H	0 (0%)	0 (0%)	0 (0%)	0 (0%)	5 (100%)	0 (0%)	0 (0%)	0 (0%)	5 (23.8%)
PD_Code									
A	0 (0%)	0 (0%)	0 (0%)	3 (100%)	0 (0%)	4 (100%)	0 (0%)	1 (100%)	8 (38.1%)
B	3 (100%)	0 (0%)	0 (0%)	0 (0%)	5 (100%)	0 (0%)	0 (0%)	0 (0%)	8 (38.1%)
C	0 (0%)	2 (100%)	1 (100%)	0 (0%)	0 (0%)	0 (0%)	2 (100%)	0 (0%)	5 (23.8%)
Sample									
a	2 (66.7%)	2 (100%)	1 (100%)	2 (66.7%)	2 (40.0%)	2 (50.0%)	2 (100%)	1 (100%)	14 (66.7%)
q	1 (33.3%)	0 (0%)	0 (0%)	1 (33.3%)	3 (60.0%)	2 (50.0%)	0 (0%)	0 (0%)	7 (33.3%)

	FJI (N=3)	KIR (N=2)	MHL (N=1)	NIU (N=3)	PLW (N=5)	SLB (N=4)	TUV (N=2)	VUT (N=1)	Overall (N=21)
TEQ_DF (pg TEQ/PUF)									
Mean (SD)	8.46 (6.62)	0.576 (0.438)	0.000495 (NA)	0.0725 (0.0769)	2.69 (2.99)	16.7 (8.51)	0.235 (0.0421)	2.05 (NA)	5.22 (7.55)
Median [Min, Max]	10.7 [1.01, 13.6]	0.576 [0.267, 0.886]	0.000495 [0.000495, 0.000495]	0.0634 [0.000538, 0.154]	1.49 [0.0433, 7.70]	15.5 [8.72, 27.0]	0.235 [0.205, 0.265]	2.05 [2.05, 2.05]	1.24 [0.000495, 27.0]
TEQ_PCB (pg TEQ/PUF)									
Mean (SD)	3.04 (1.60)	0.151 (0.209)	0.00234 (NA)	0.0134 (0.000939)	0.768 (0.239)	2.26 (0.277)	0.432 (0.0771)	0.0125 (NA)	1.11 (1.25)
Median [Min, Max]	3.54 [1.25, 4.32]	0.151 [0.00326, 0.299]	0.00234 [0.00234, 0.00234]	0.0138 [0.0124, 0.0141]	0.675 [0.517, 1.14]	2.23 [2.01, 2.56]	0.432 [0.378, 0.487]	0.0125 [0.0125, 0.0125]	0.661 [0.00234, 4.32]

Country

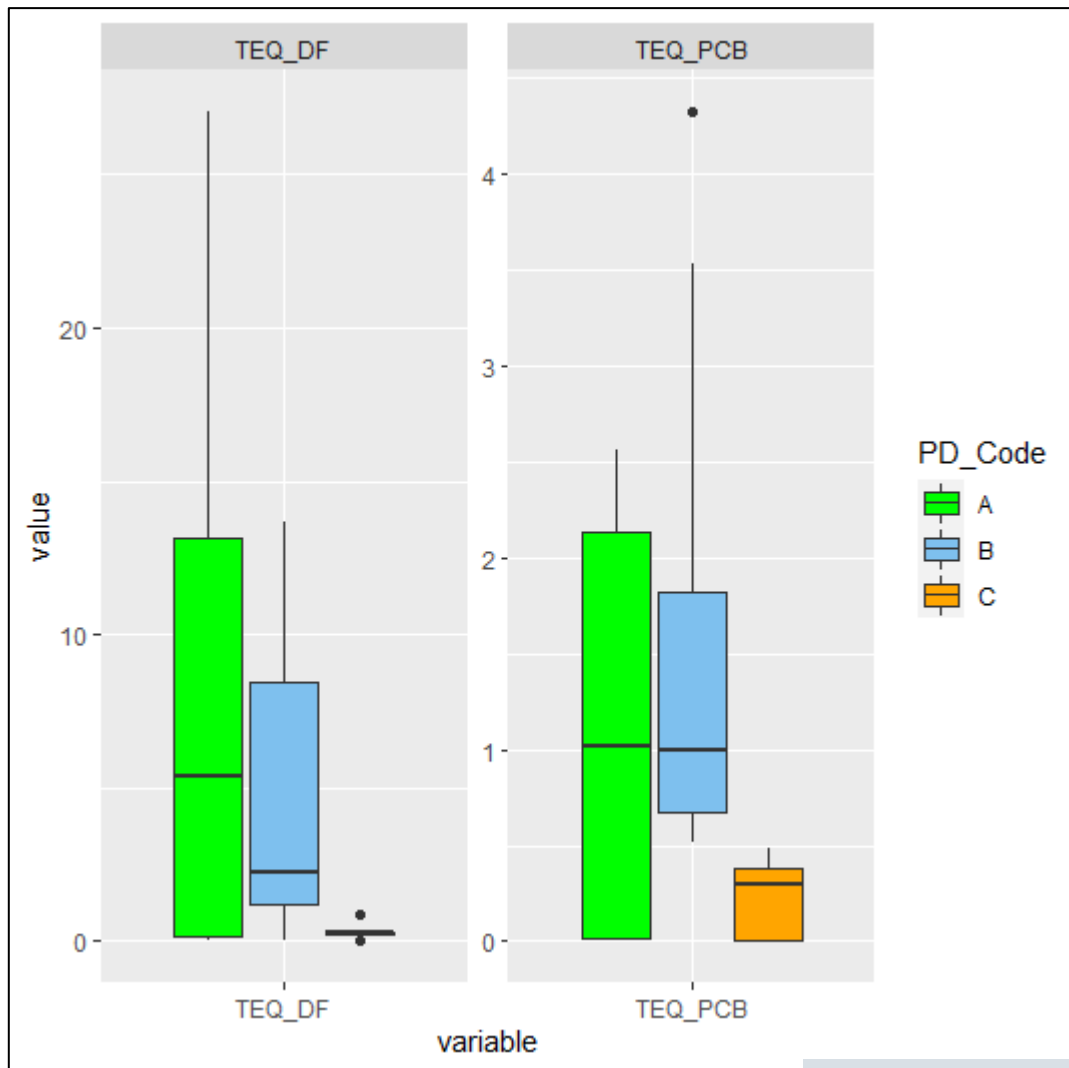


Sampling year

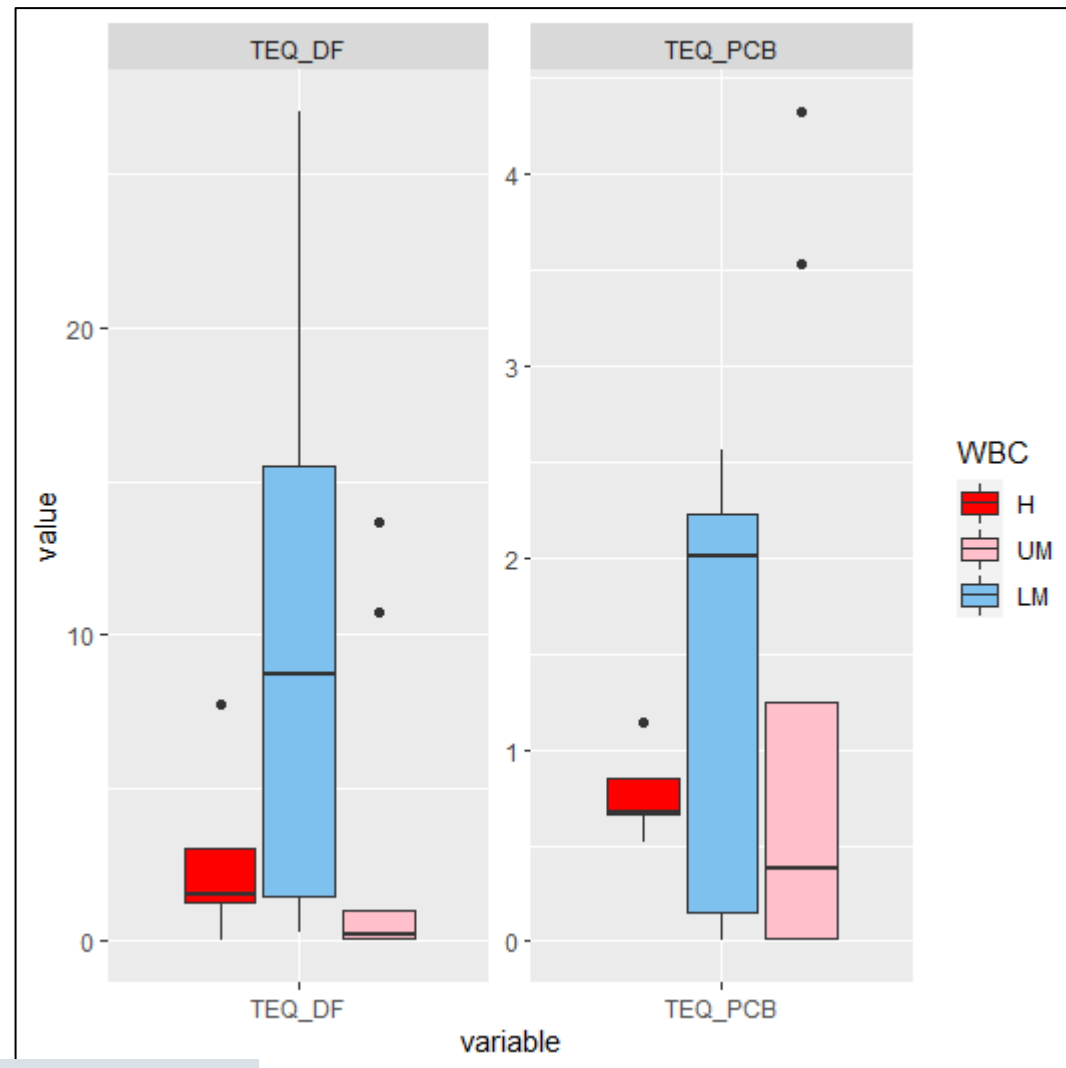


Values in pg WHO₂₀₀₅-TEQ/PUF

Population density

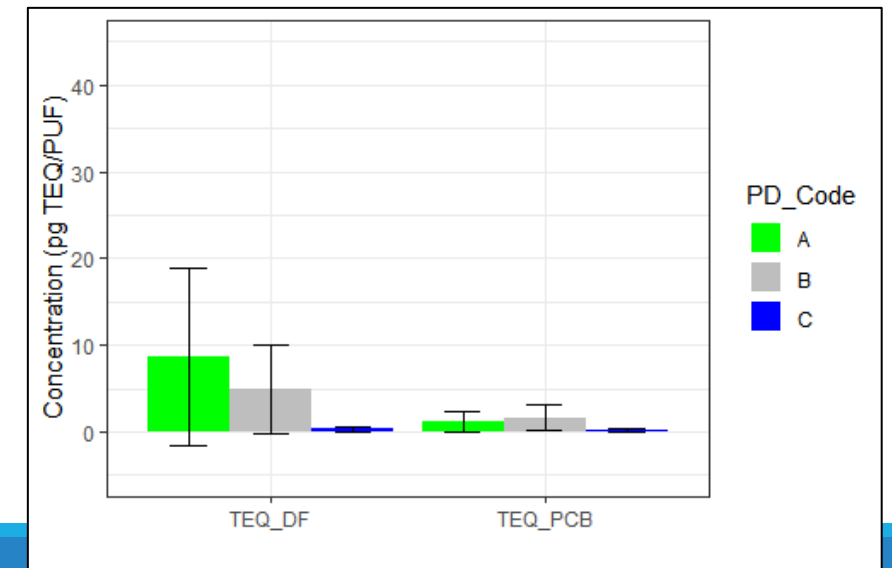
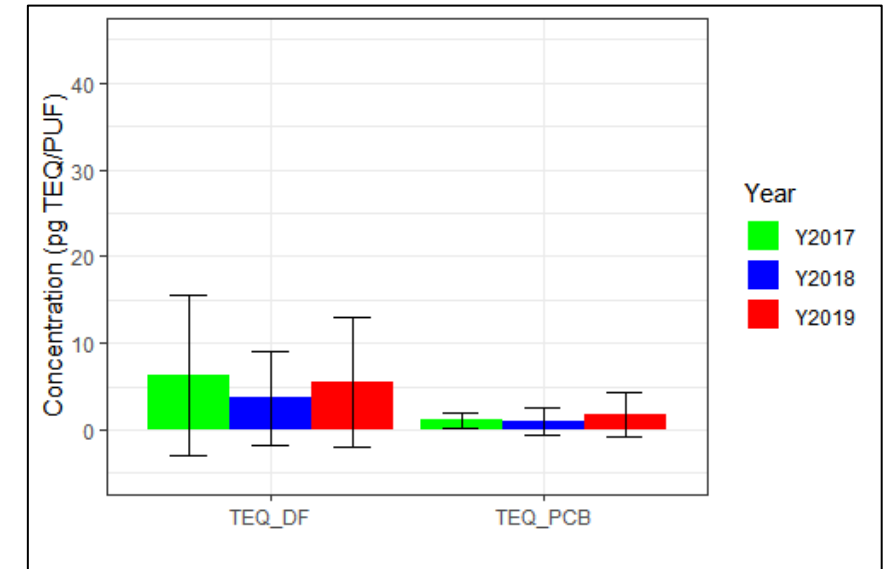
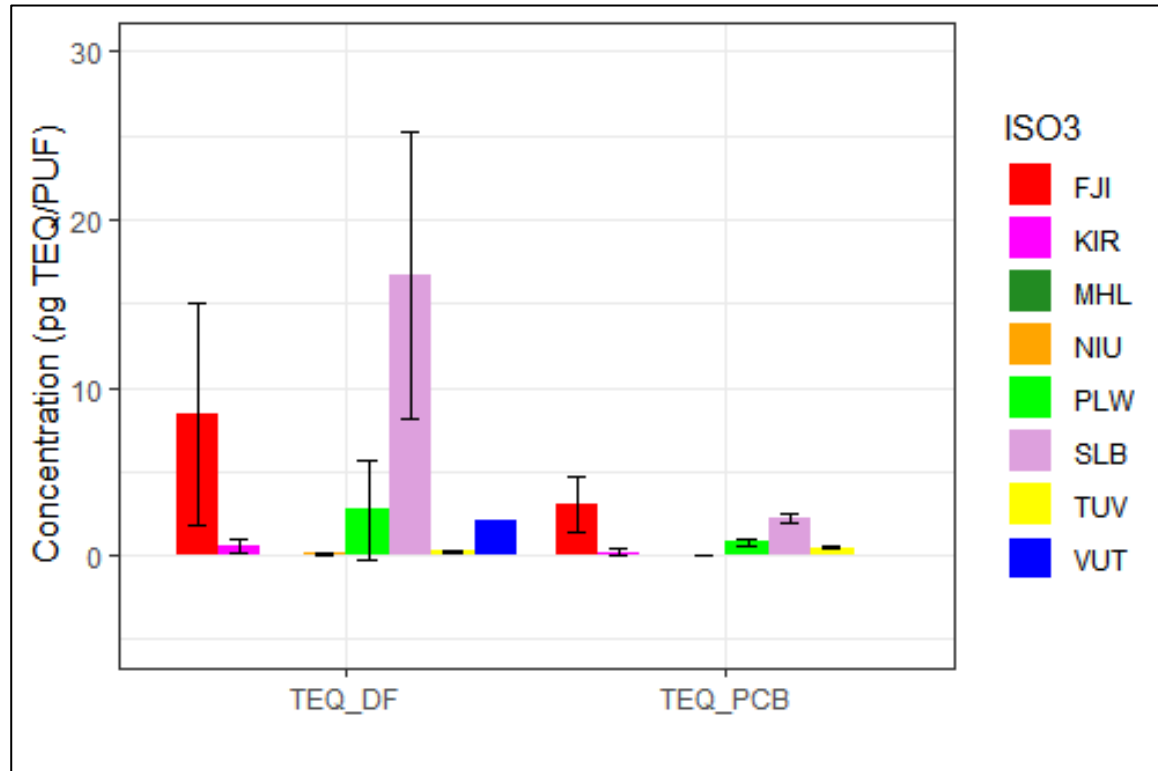


Income



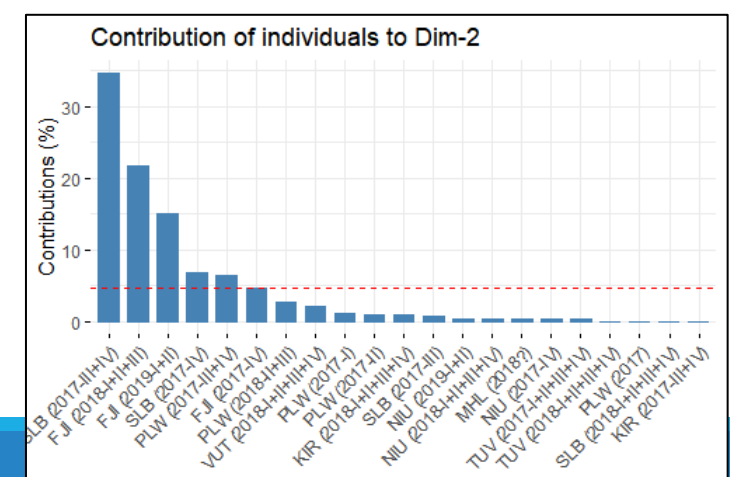
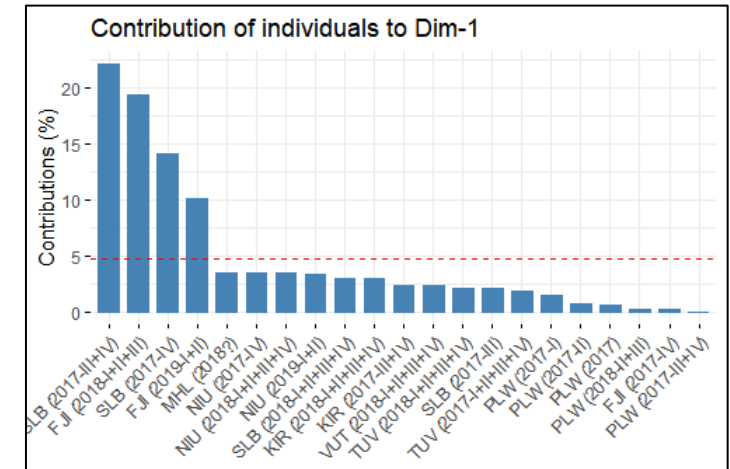
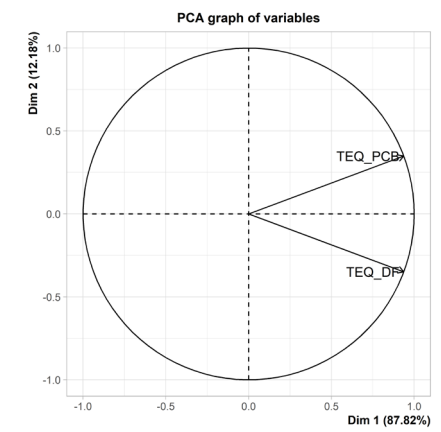
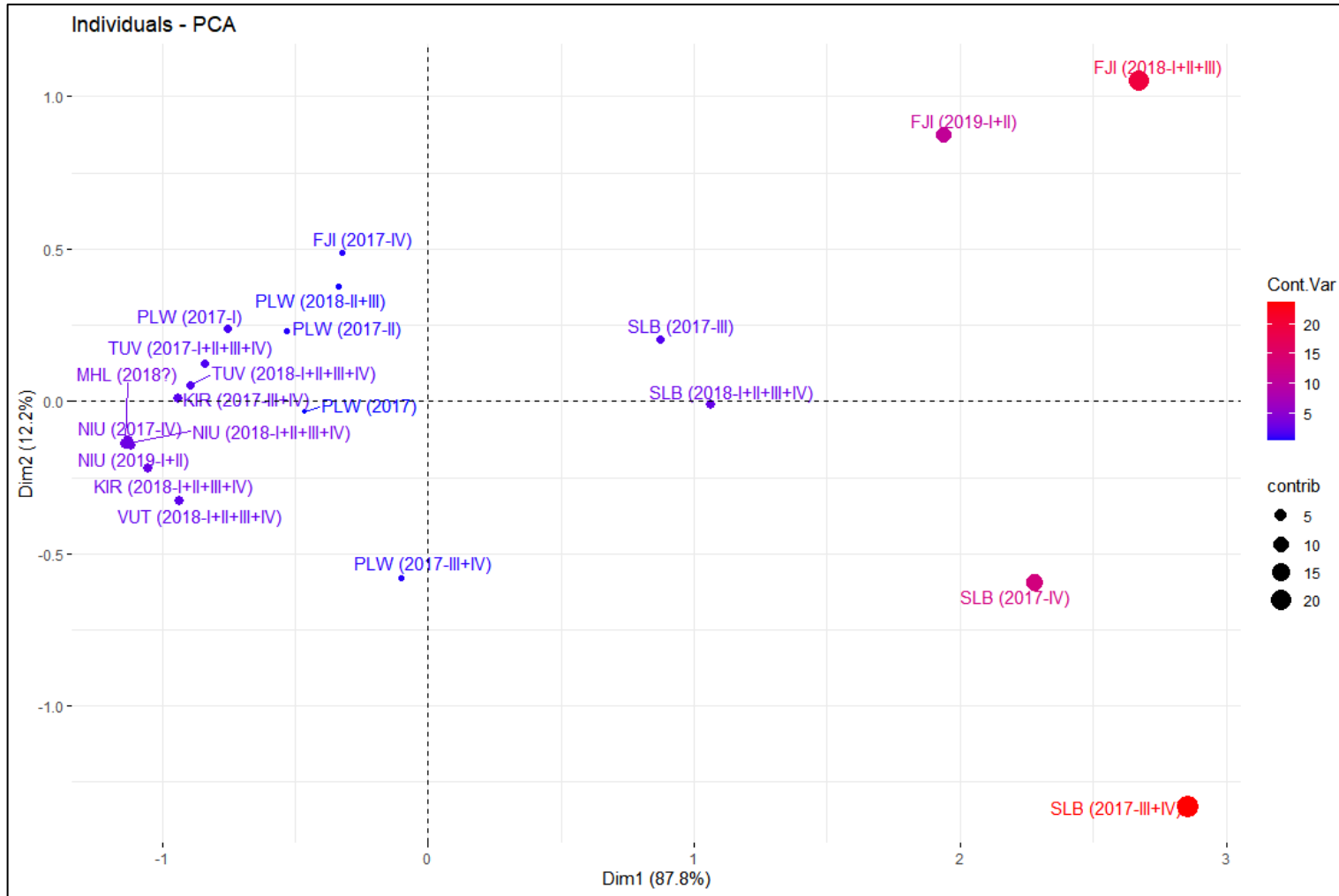
Values in pg WHO₂₀₀₅-TEQ/PUF

Mean values and standard deviation

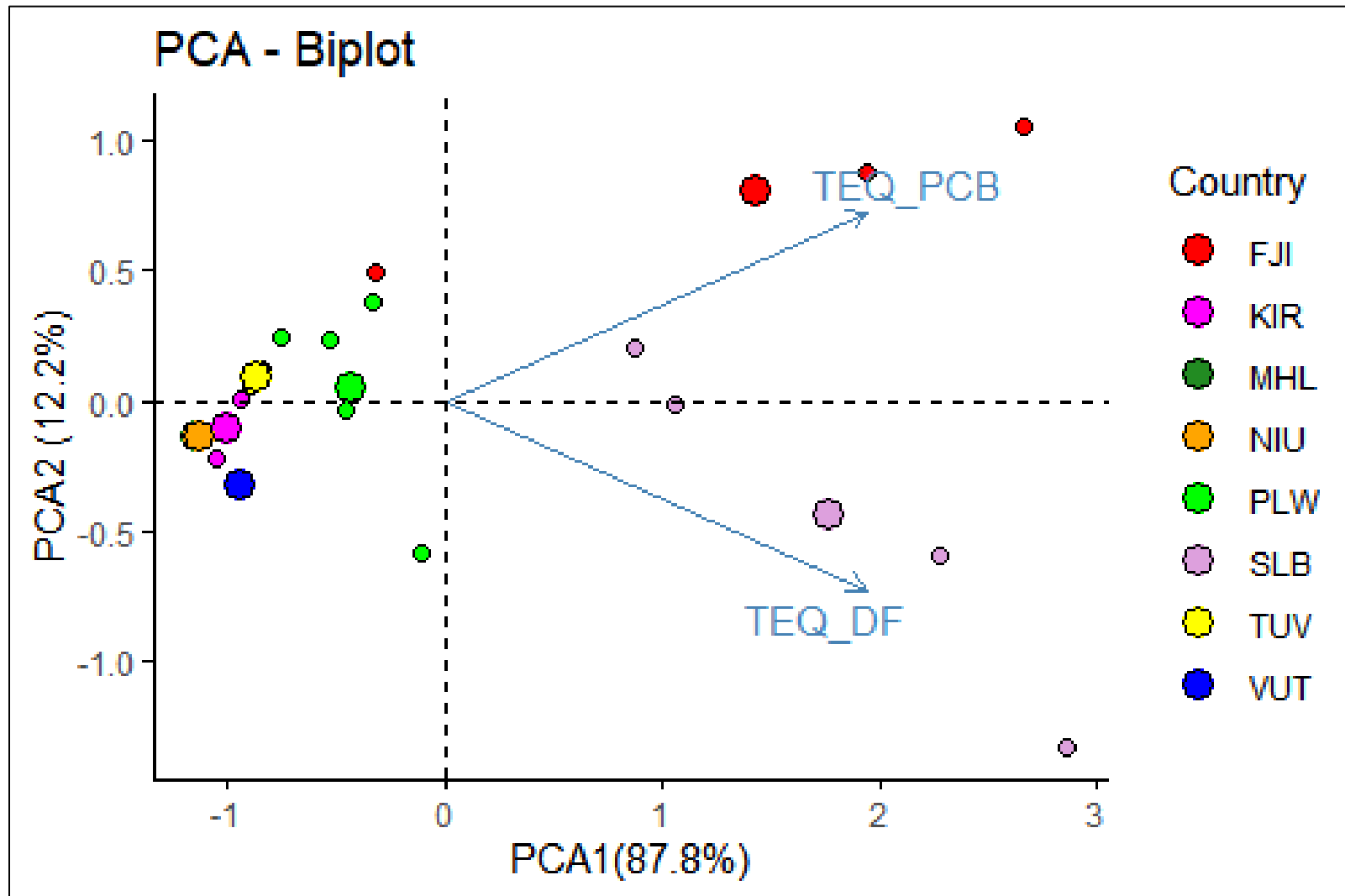


Values in pg WHO₂₀₀₅-TEQ/PUF

PCA, contribution to variation



PCA, by sample and country

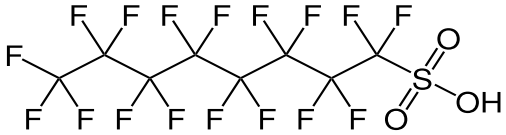

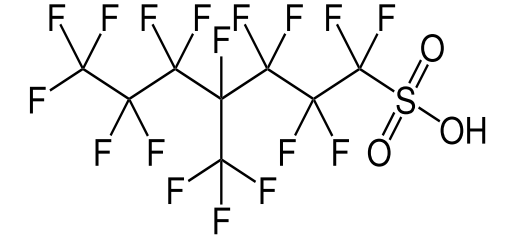
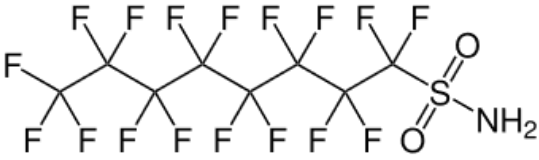


PAS/PUF Results - PFAS

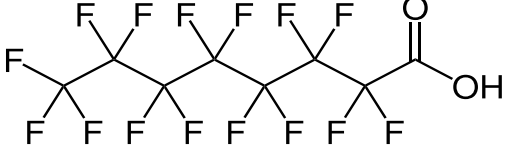
B. Across All Projects

Perfluoroalkane substances (PFAS)

Perfluoroalkylsulfonic acids (PFSA)

	PFOS	PFHxS
L-PFOS		 L-PFHxS
br-PFOS		
FOSA (PFOS pre-cursor)		

Perfluoroalkylcarboxylic acids (PFCA)

	PFOA
L-PFOA	

Number/classification of samples GMP2 PFAS

	Africa (N=127)	Asia (N=46)	GRULAC (N=101)	PAC (N=43)	Overall (N=317)
Region					
Africa	127 (100%)	0 (0%)	0 (0%)	0 (0%)	127 (40.1%)
Asia	0 (0%)	46 (100%)	0 (0%)	0 (0%)	46 (14.5%)
GRULAC	0 (0%)	0 (0%)	101 (100%)	0 (0%)	101 (31.9%)
PAC	0 (0%)	0 (0%)	0 (0%)	43 (100%)	43 (13.6%)
WBC					
L	52 (40.9%)	0 (0%)	0 (0%)	0 (0%)	52 (16.4%)
LM	65 (51.2%)	40 (87.0%)	0 (0%)	20 (46.5%)	125 (39.4%)
UM	10 (7.9%)	6 (13.0%)	58 (57.4%)	15 (34.9%)	89 (28.1%)
H	0 (0%)	0 (0%)	43 (42.6%)	8 (18.6%)	51 (16.1%)
PD_Code					
A	19 (15.0%)	9 (19.6%)	34 (33.7%)	18 (41.9%)	80 (25.2%)
B	55 (43.3%)	14 (30.4%)	38 (37.6%)	13 (30.2%)	120 (37.9%)
C	43 (33.9%)	23 (50.0%)	19 (18.8%)	12 (27.9%)	97 (30.6%)
D	10 (7.9%)	0 (0%)	10 (9.9%)	0 (0%)	20 (6.3%)

Quantifiable,
includes ZMB

Number/classification of samples GMP2 PFAS

Without outliers

	Africa (N=119)	Asia (N=46)	GRULAC (N=101)	PAC (N=43)	Overall (N=309)
Region					
Africa	119 (100%)	0 (0%)	0 (0%)	0 (0%)	119 (38.5%)
Asia	0 (0%)	46 (100%)	0 (0%)	0 (0%)	46 (14.9%)
GRULAC	0 (0%)	0 (0%)	101 (100%)	0 (0%)	101 (32.7%)
PAC	0 (0%)	0 (0%)	0 (0%)	43 (100%)	43 (13.9%)
WBC					
L	52 (43.7%)	0 (0%)	0 (0%)	0 (0%)	52 (16.8%)
LM	57 (47.9%)	40 (87.0%)	0 (0%)	20 (46.5%)	117 (37.9%)
UM	10 (8.4%)	6 (13.0%)	58 (57.4%)	15 (34.9%)	89 (28.8%)
H	0 (0%)	0 (0%)	43 (42.6%)	8 (18.6%)	51 (16.5%)
PD_Code					
A	11 (9.2%)	9 (19.6%)	34 (33.7%)	18 (41.9%)	72 (23.3%)
B	55 (46.2%)	14 (30.4%)	38 (37.6%)	13 (30.2%)	120 (38.8%)
C	43 (36.1%)	23 (50.0%)	19 (18.8%)	12 (27.9%)	97 (31.4%)
D	10 (8.4%)	0 (0%)	10 (9.9%)	0 (0%)	20 (6.5%)
YYYY					
Y2017	54 (45.4%)	9 (19.6%)	47 (46.5%)	15 (34.9%)	125 (40.5%)
Y2018	58 (48.7%)	29 (63.0%)	54 (53.5%)	26 (60.5%)	167 (54.0%)
Y2019	7 (5.9%)	8 (17.4%)	0 (0%)	2 (4.7%)	17 (5.5%)
Sample					
a	24 (20.2%)	8 (17.4%)	21 (20.8%)	9 (20.9%)	62 (20.1%)
q	95 (79.8%)	38 (82.6%)	80 (79.2%)	34 (79.1%)	247 (79.9%)

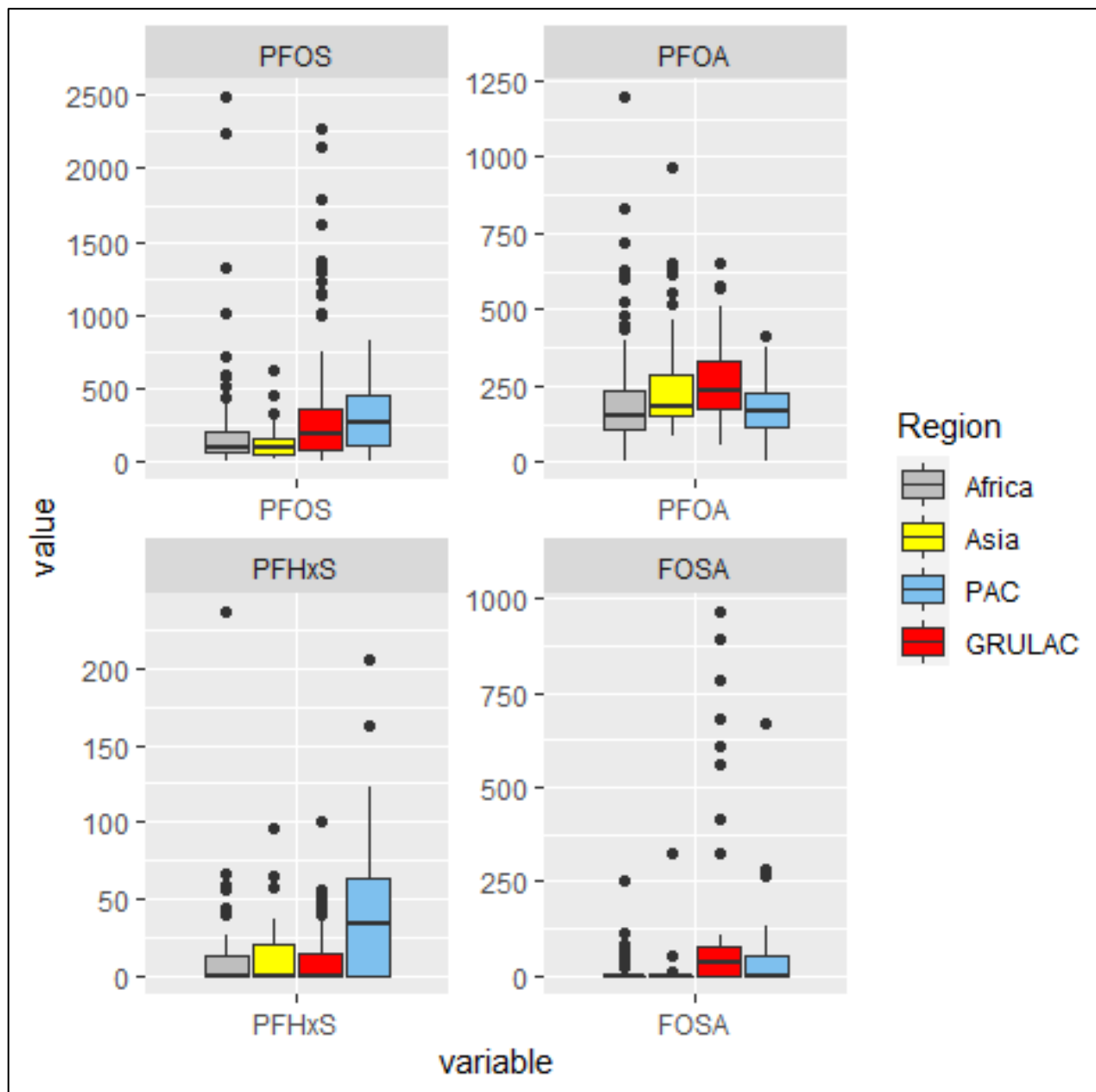
Summary results PAS/PUFs for PFAS (without outliers)

	Africa (N=119)	Asia (N=46)	GRULAC (N=101)	PAC (N=43)	Overall (N=309)
PFOS (pg/PUF)					
Mean (SD)	203 (346)	139 (122)	376 (497)	297 (219)	261 (375)
Median [Min, Max]	98.1 [0, 2480]	101 [27.3, 634]	192 [0, 2260]	266 [0, 827]	128 [0, 2480]
Missing	5 (4.2%)	1 (2.2%)	10 (9.9%)	3 (7.0%)	19 (6.1%)
PFOA (pg/PUF)					
Mean (SD)	206 (177)	271 (194)	257 (125)	181 (86.5)	230 (157)
Median [Min, Max]	149 [0, 1190]	183 [83.1, 965]	233 [58.9, 655]	165 [0, 417]	187 [0, 1190]
Missing	10 (8.4%)	2 (4.3%)	5 (5.0%)	5 (11.6%)	22 (7.1%)
PFHxS (pg/PUF)					
Mean (SD)	8.96 (24.8)	13.4 (20.7)	9.72 (18.6)	41.6 (48.5)	14.5 (29.3)
Median [Min, Max]	0 [0, 237]	0 [0, 96.1]	0 [0, 101]	34.7 [0, 206]	0 [0, 237]
Missing	2 (1.7%)	2 (4.3%)	1 (1.0%)	0 (0%)	5 (1.6%)
FOSA					
Mean (SD)	16.5 (40.6)	24.6 (81.8)	138 (260)	68.5 (155)	64.3 (171)
Median [Min, Max]	0 [0, 251]	0 [0, 327]	34.9 [0, 964]	0 [0, 669]	0 [0, 964]
Missing	61 (51.3%)	30 (65.2%)	56 (55.4%)	20 (46.5%)	167 (54.0%)

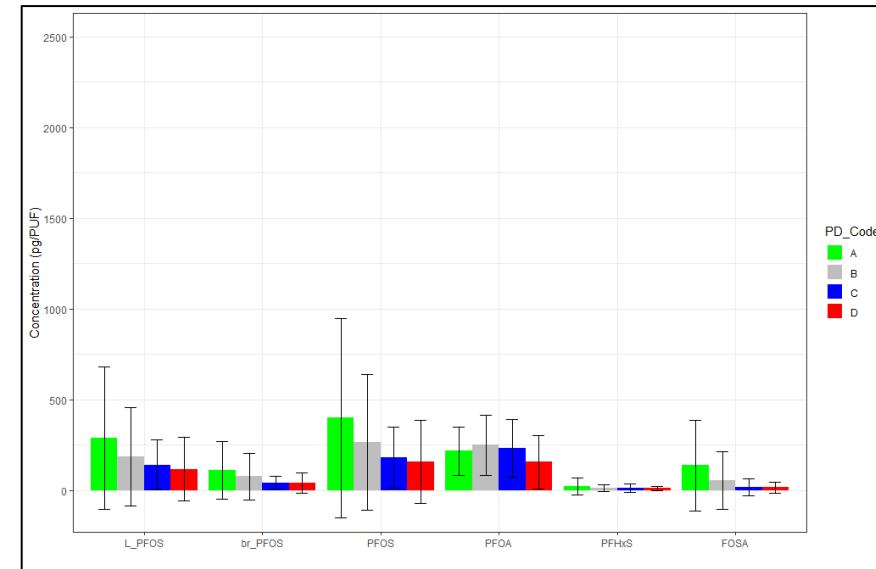
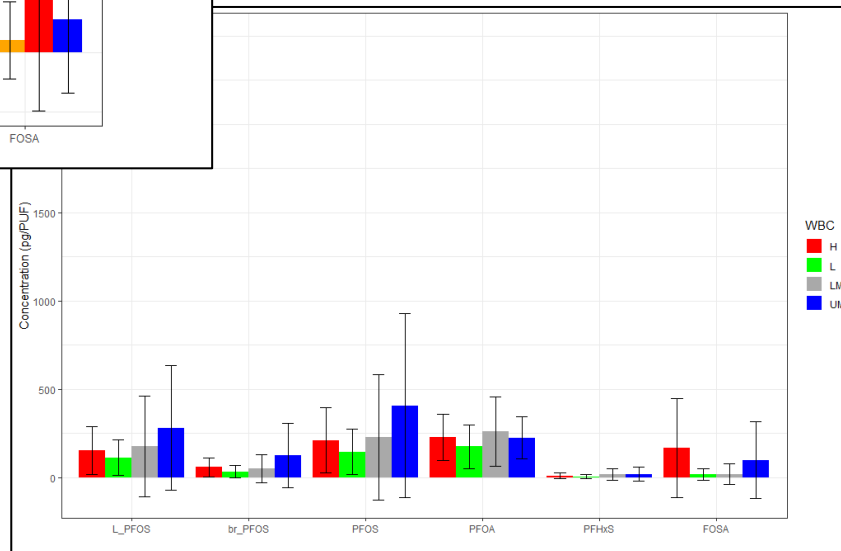
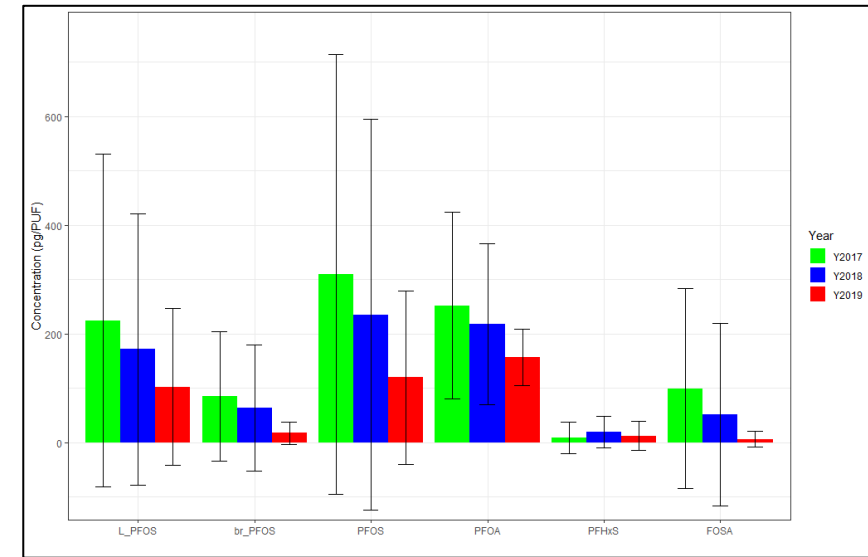
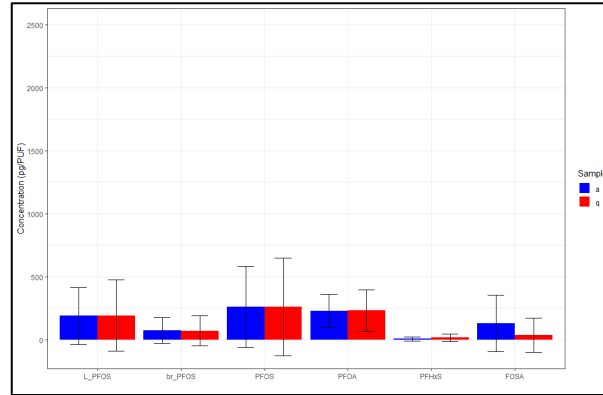
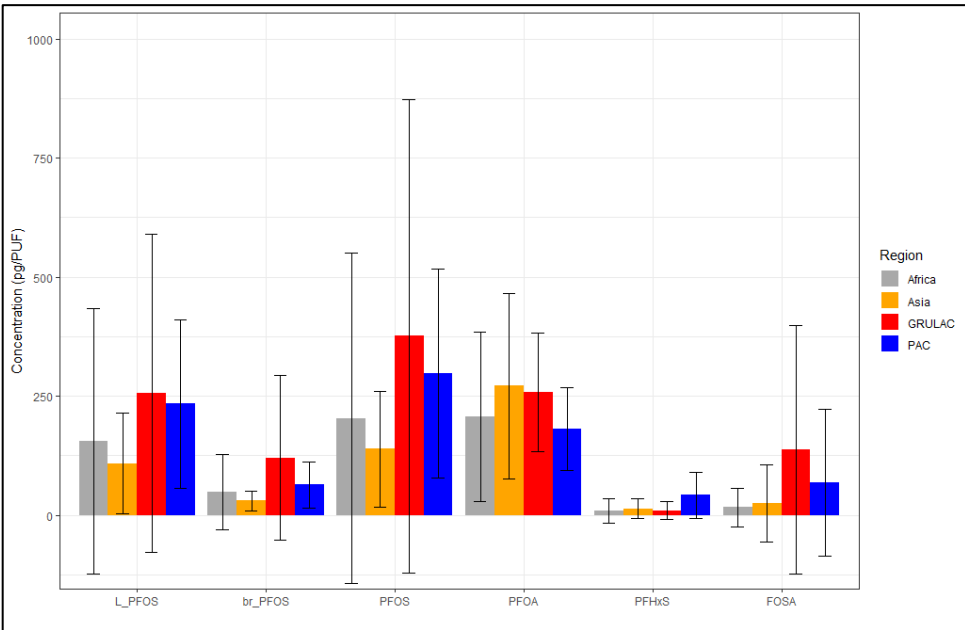
PAS/PUFs

Air (n=309)

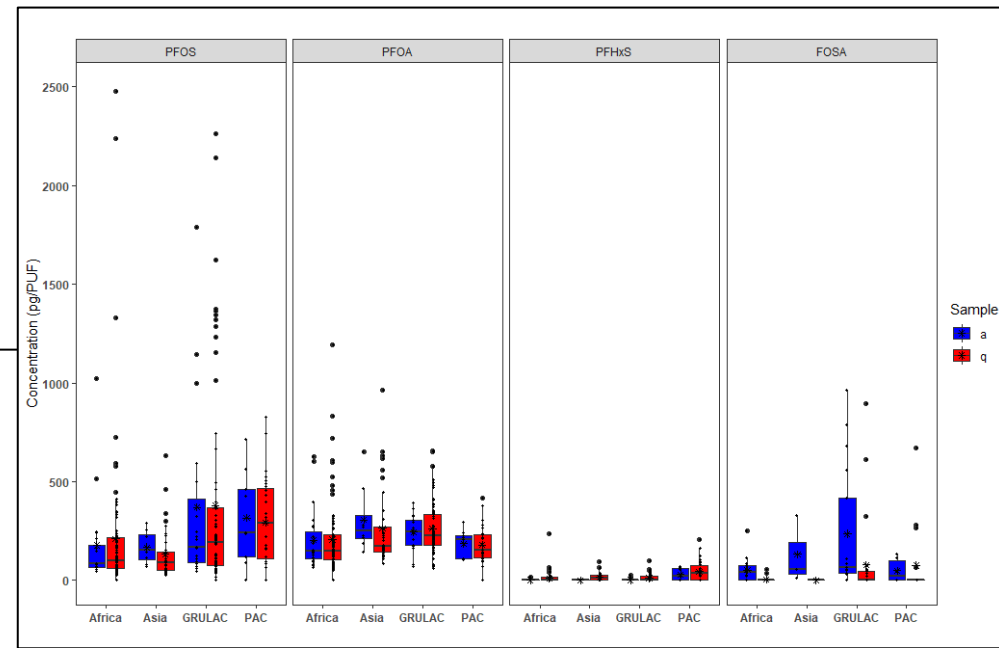
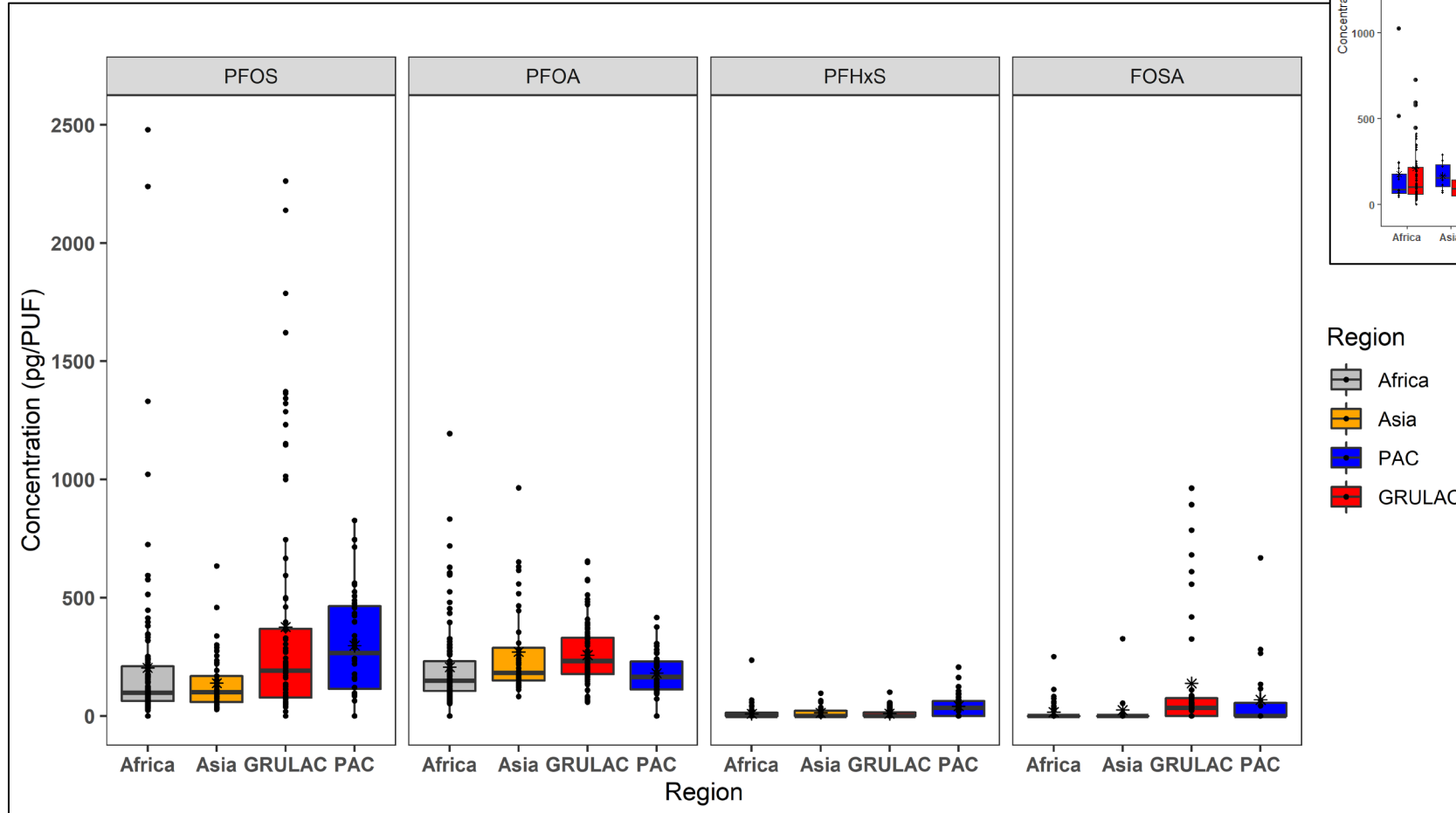
Values in pg/PUF and
3 months exposure



Mean values with SD (n=309)



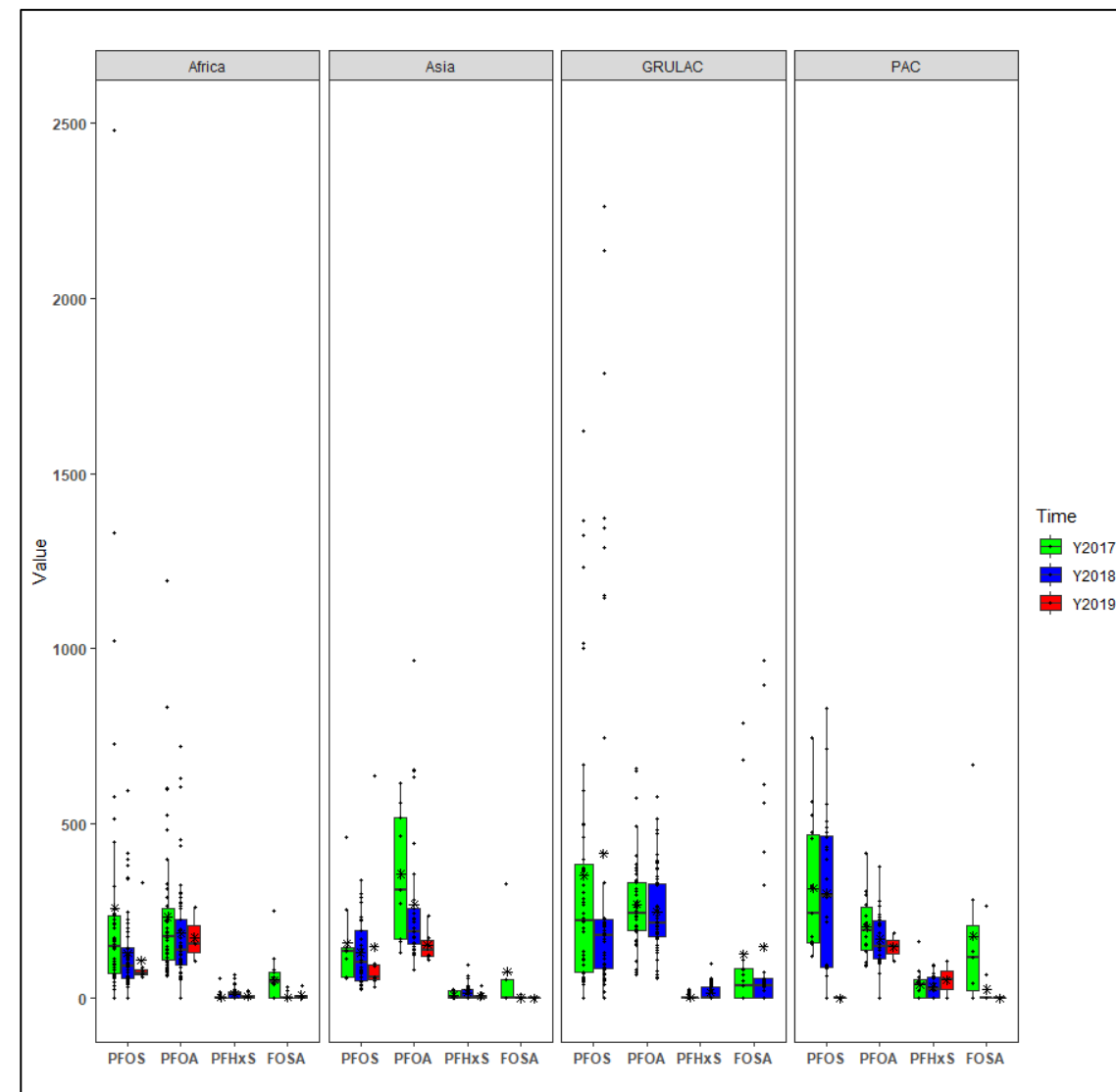
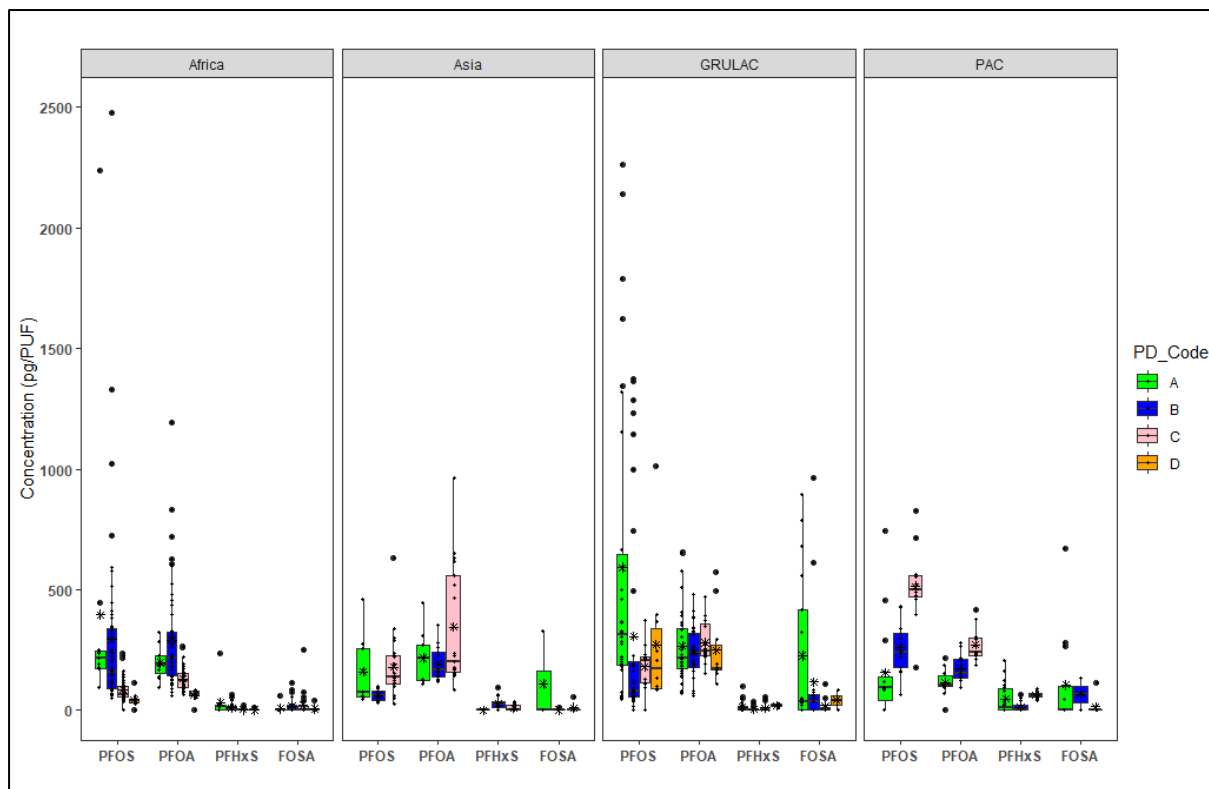
Overview PFAS by region and sample (n=309)



a = annual samples; e.g., up to 4 PUFs combined, amount divided by the number of PUFs, adjusted to 3 months

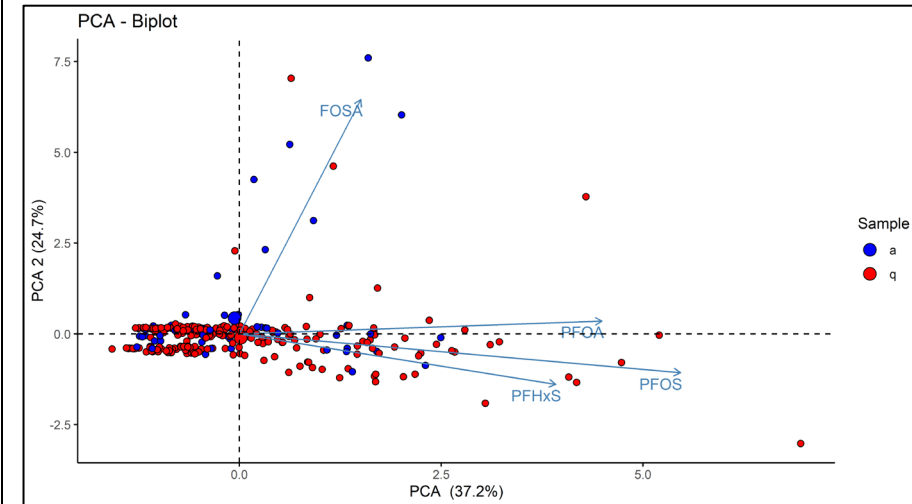
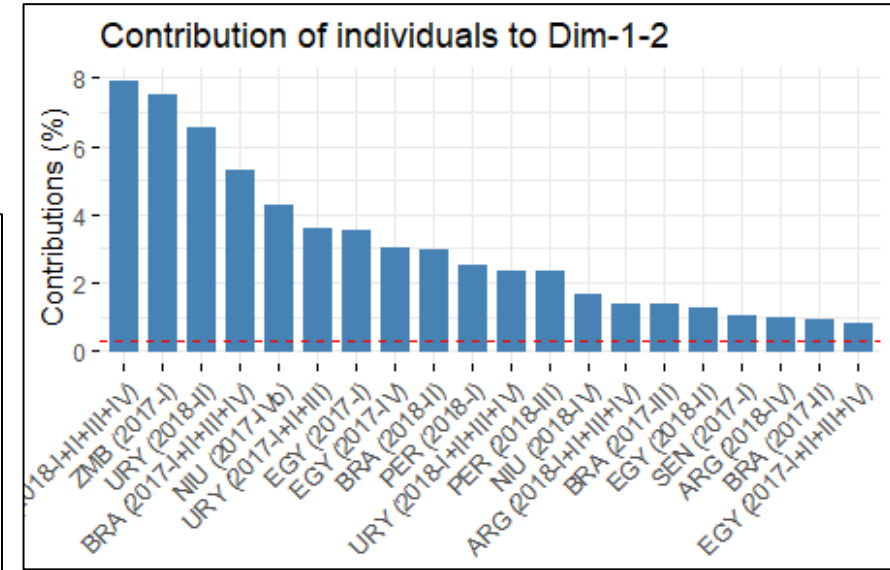
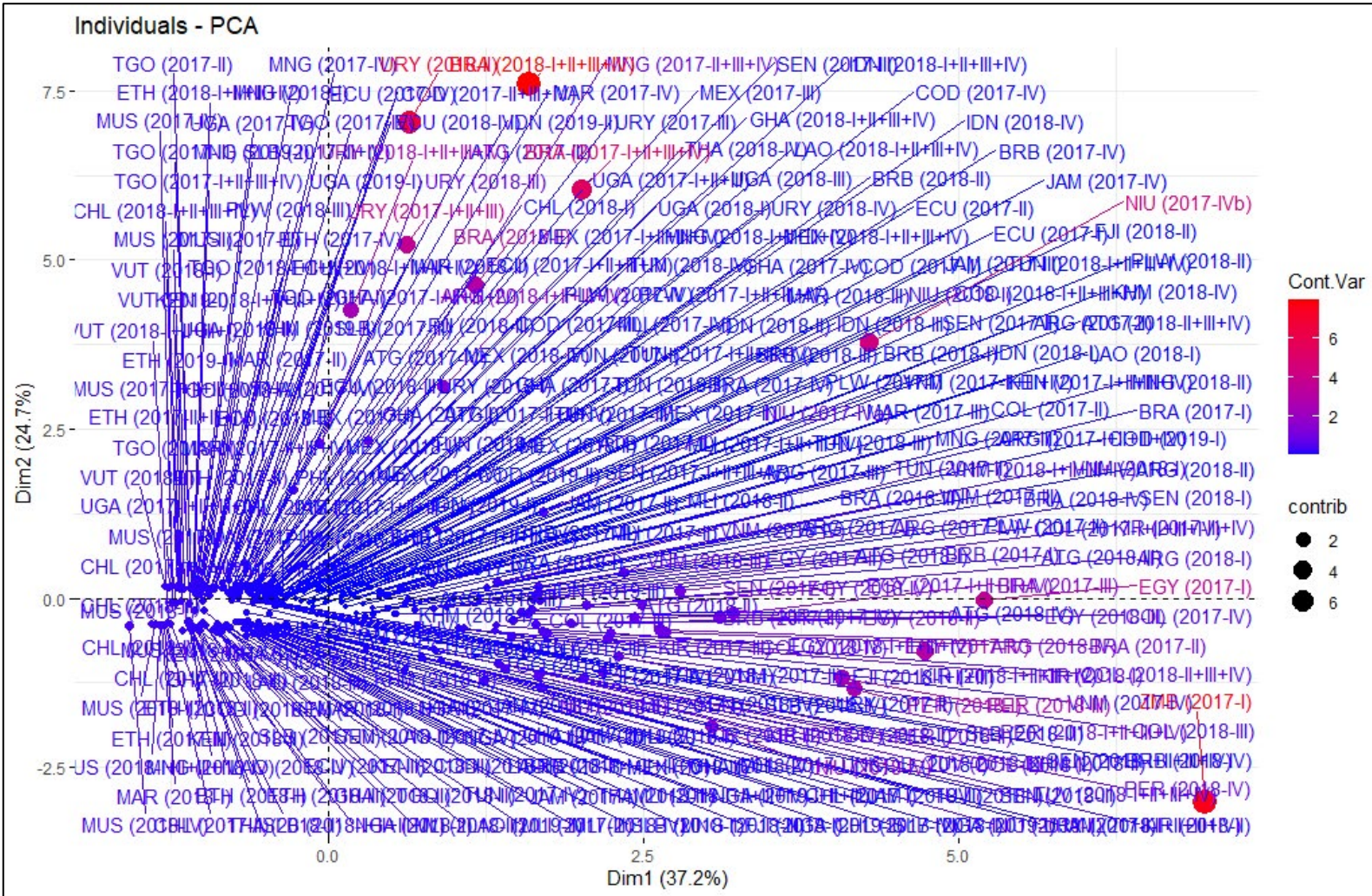
q = quarterly PUFs, 1 PUF and 3 months exposure

Overview PFAS by year and PD (n=309)

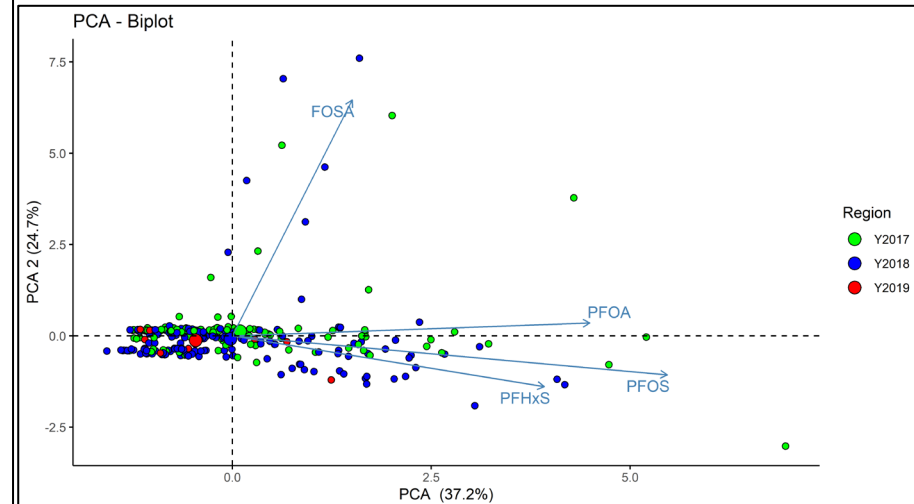
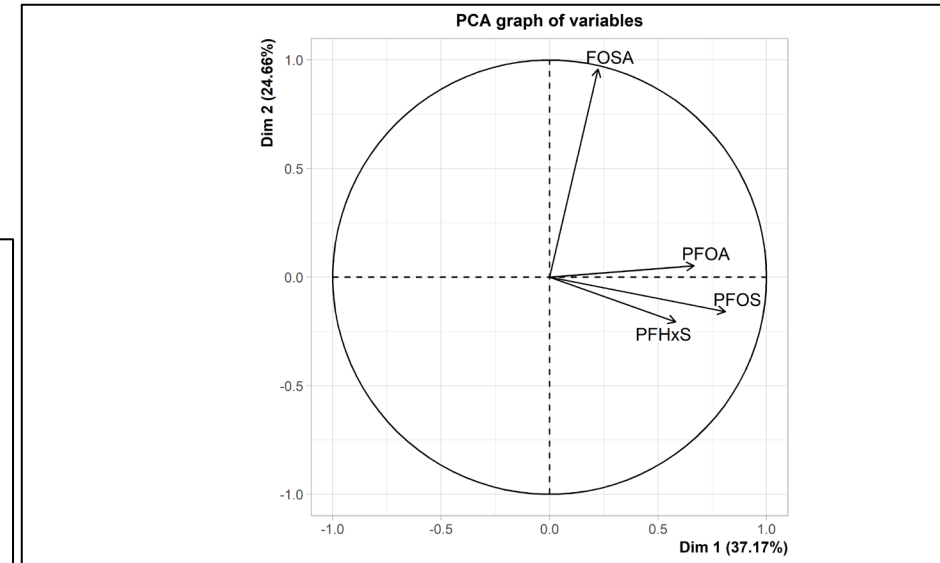
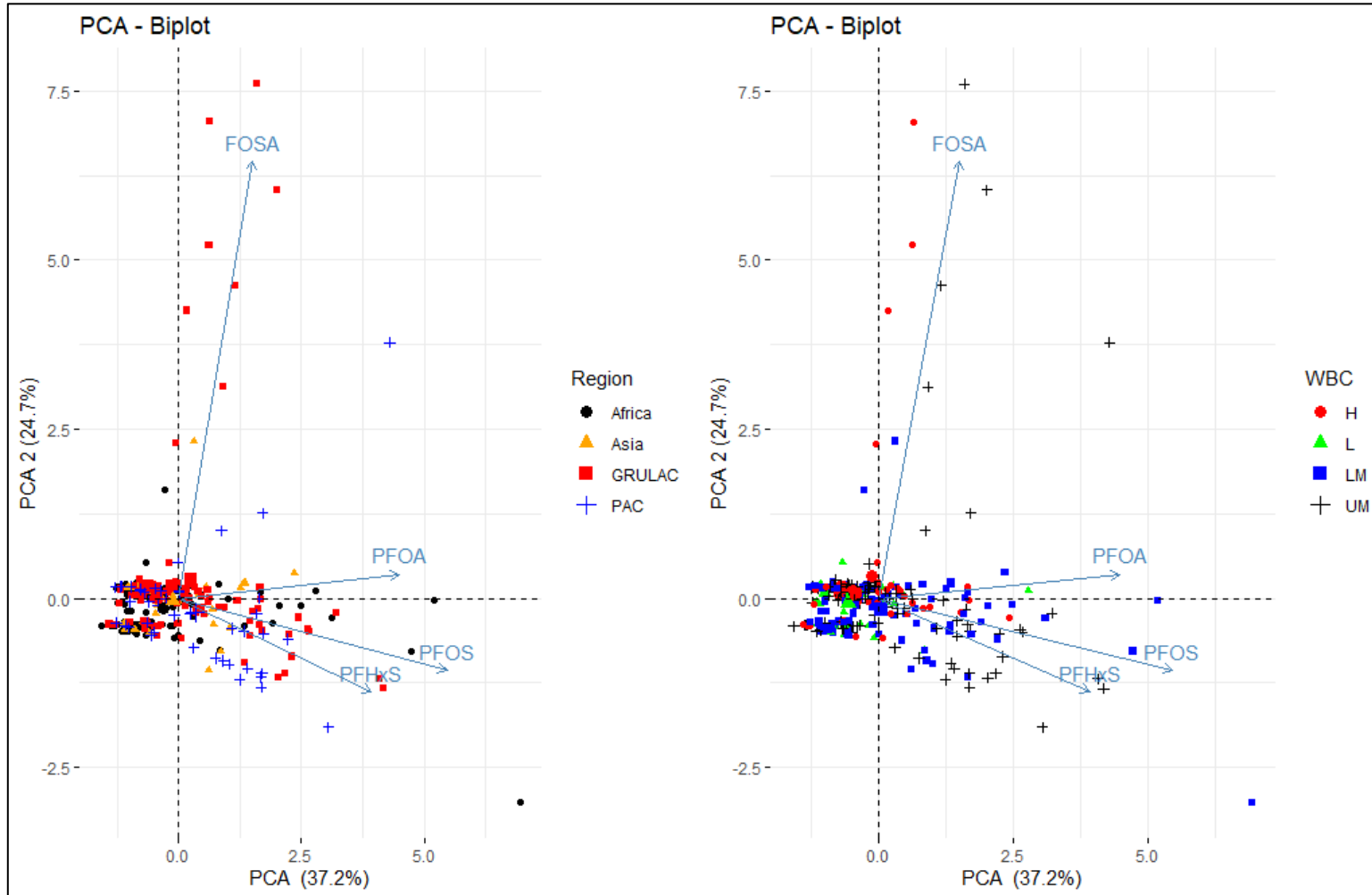


Values in pg/PUF and
3 months exposure

PCA biplot for region (n=309)



PCA biplots

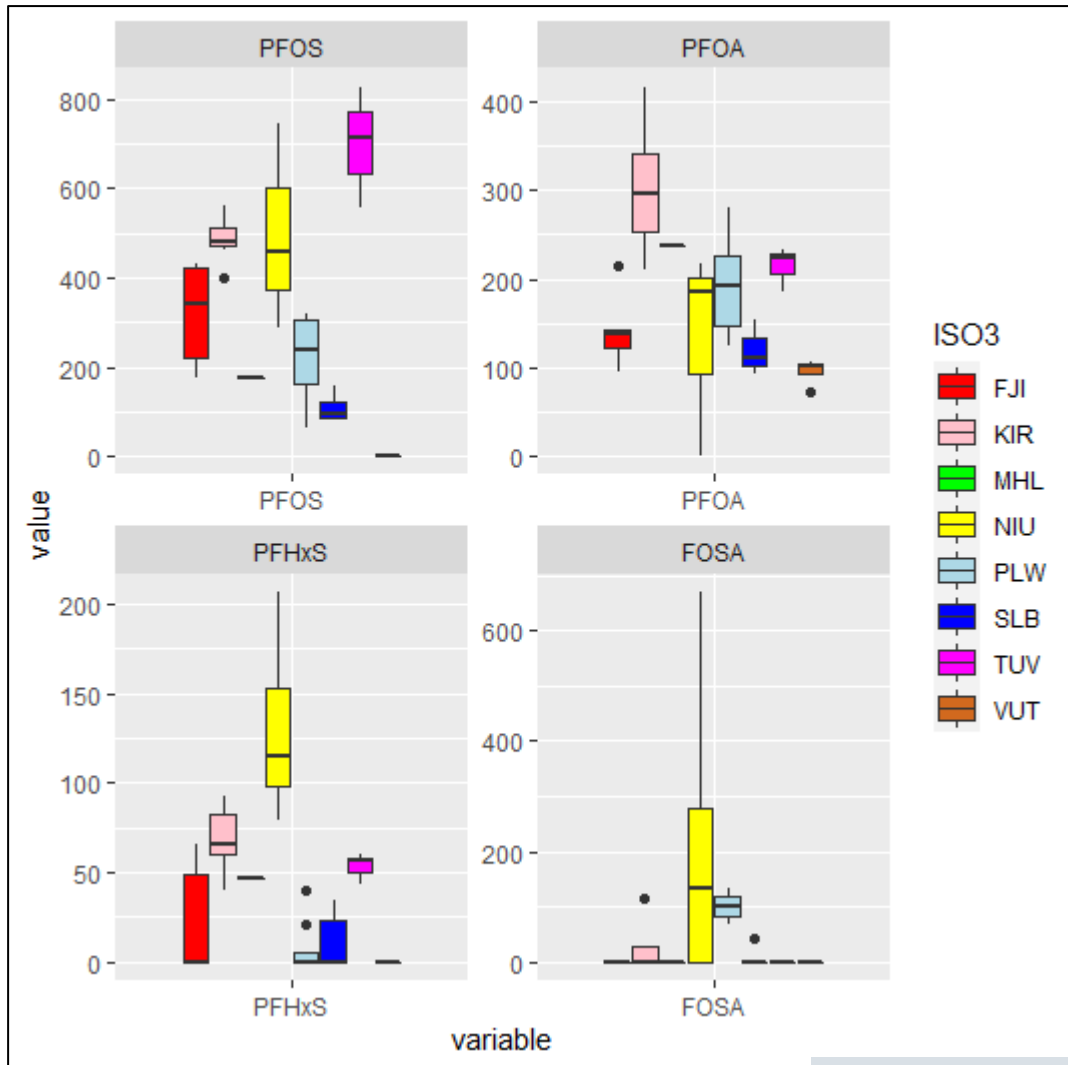


PFAS Results

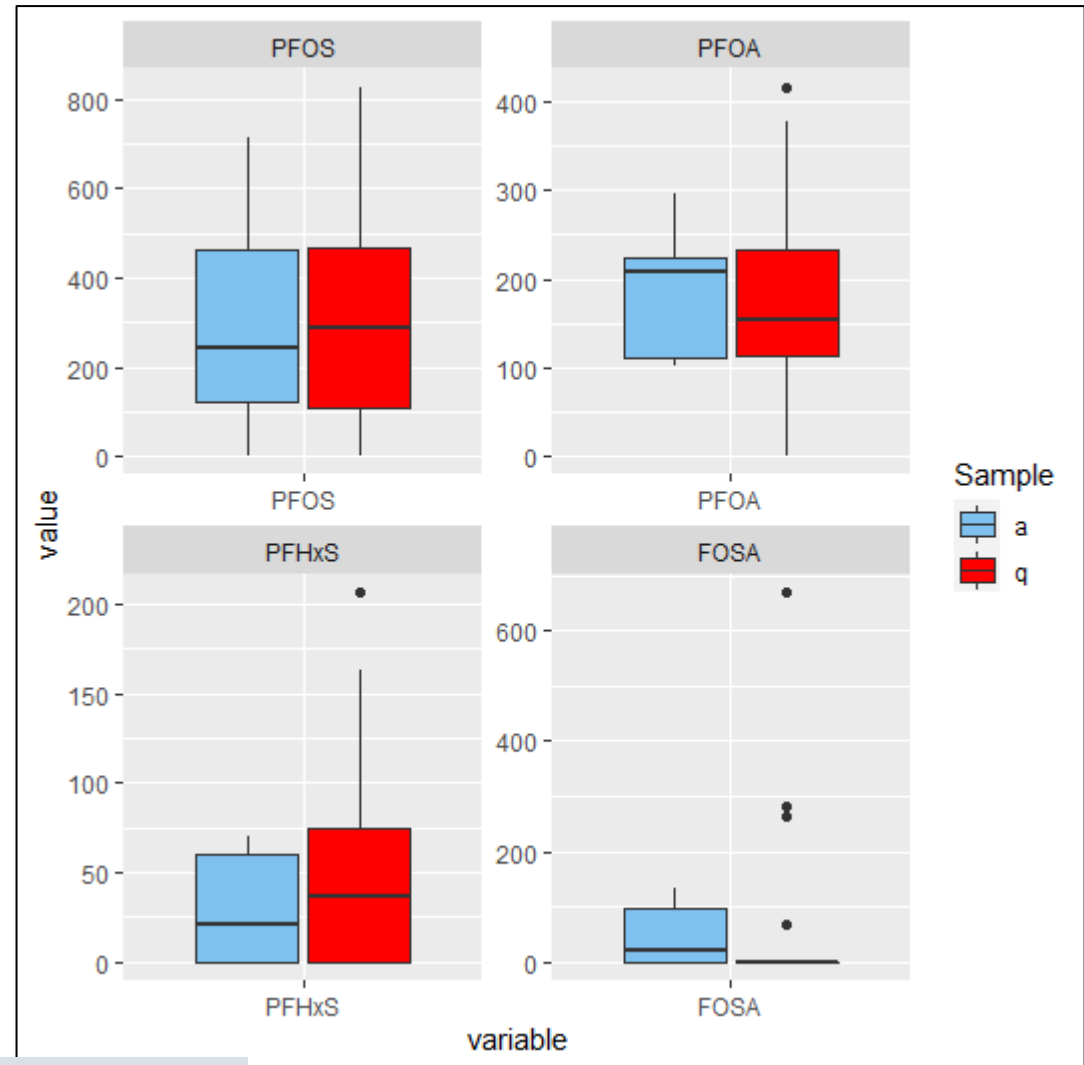
B.4 PAC Region

Country name	ISO-3	Project Region	WBC 2017	WBC 2018	PD 2017	PD 2018
Fiji	FJI	PAC	UM	UM	B	B
Kiribati	KIR	PAC	LM	LM	C	C
Marshall Islands	MHL	PAC	UM	UM	C	C
Niue	NIU	PAC	UM	UM	A	A
Palau	PLW	PAC	H	H	B	B
Samoa	WSM	PAC	UM	UM	B	B
Solomon Islands	SLB	PAC	LM	LM	A	A
Tuvalu	TUV	PAC	UM	UM	C	C
Vanuatu	VUT	PAC	LM	LM	A	A

Country

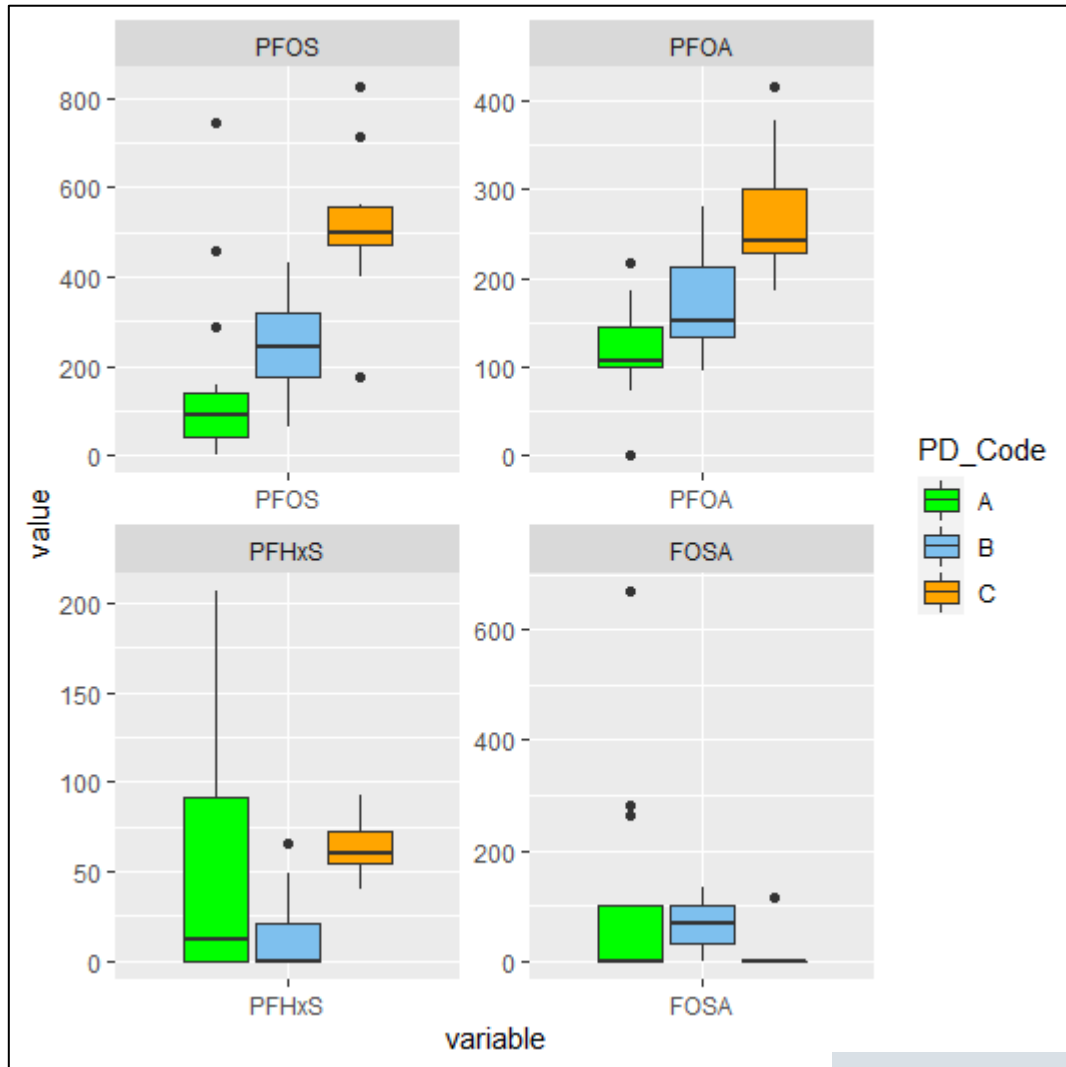


Sample year

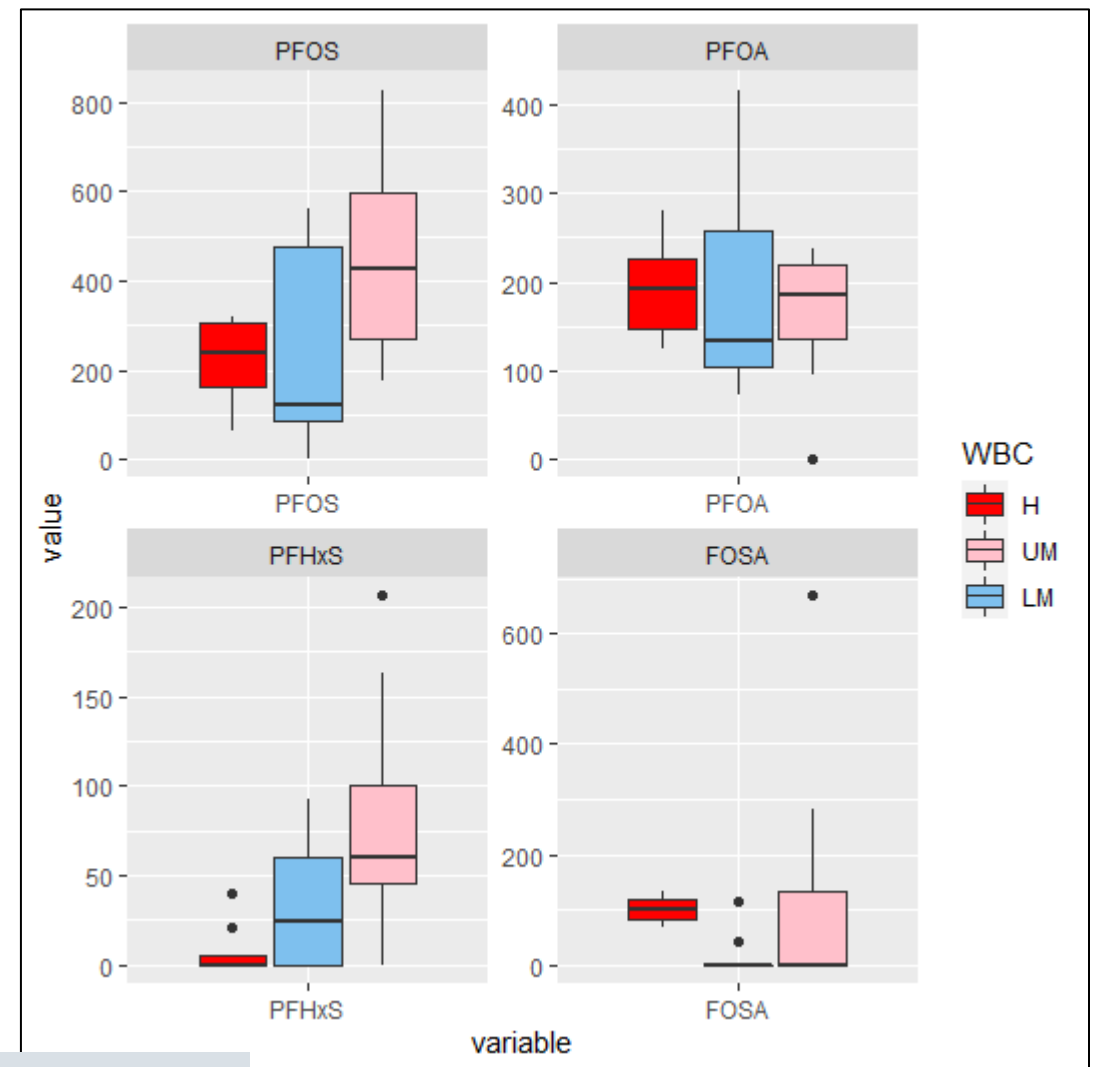


Values in pg/PUF

Population density

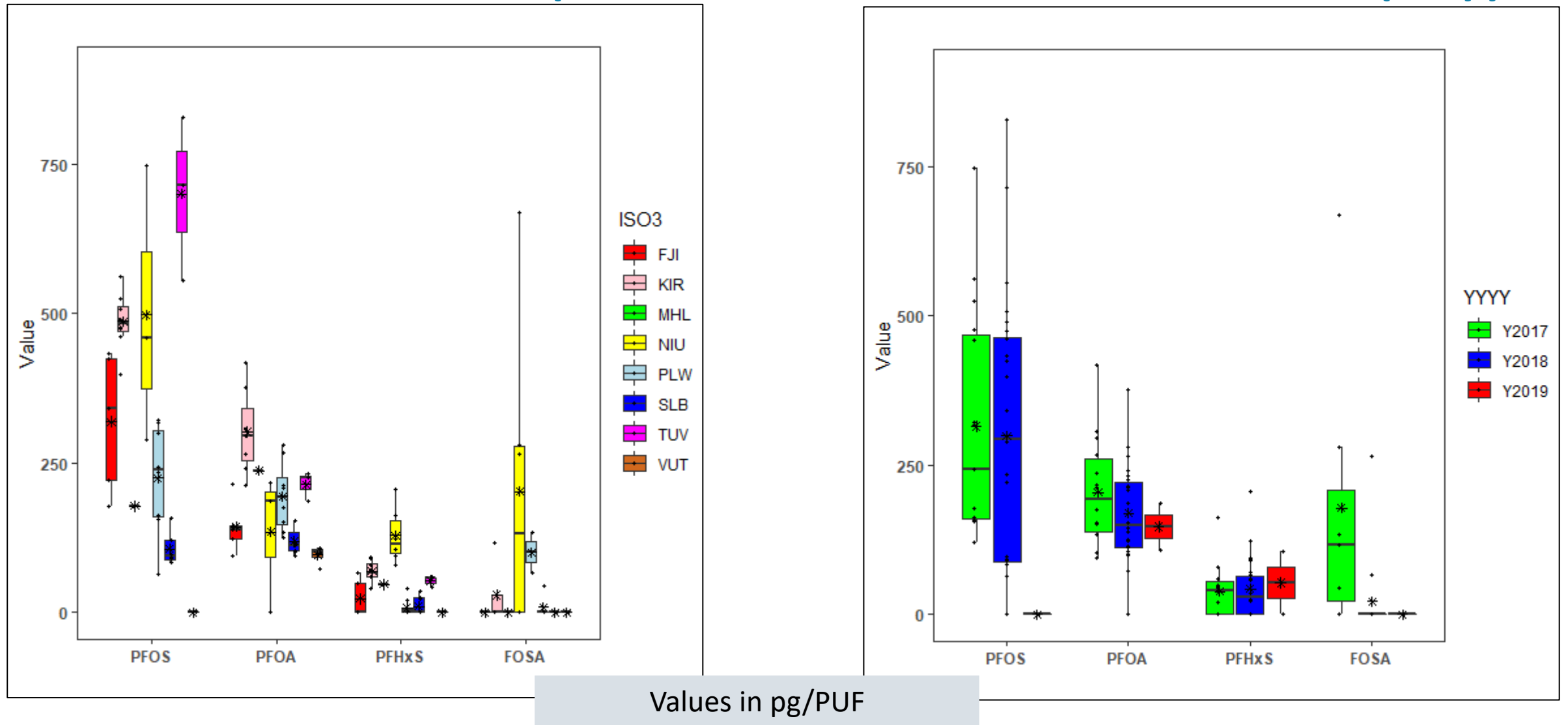


Income



Values in pg/PUF

Concentrations (with ZMB, without ZMB (-1))



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Thank you !