

PFAS in Air by Expert Laboratory



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Core matrix "air"

- PFAS
 - From GMP1: not included, no data for comparison available
 - From GMP2: More than 350 PUFs received and analyzed
 - * Some PUFs so deteriorated that no identification and quantification was possible
 - * Multiple analyses with single PUFs for PFAS and PFOS precursors (only FOSA detectable) and combinations of PUFs from the same year; esp. to quantify the PFOS precursors
 - * 9 samples from Zambia very exceptional

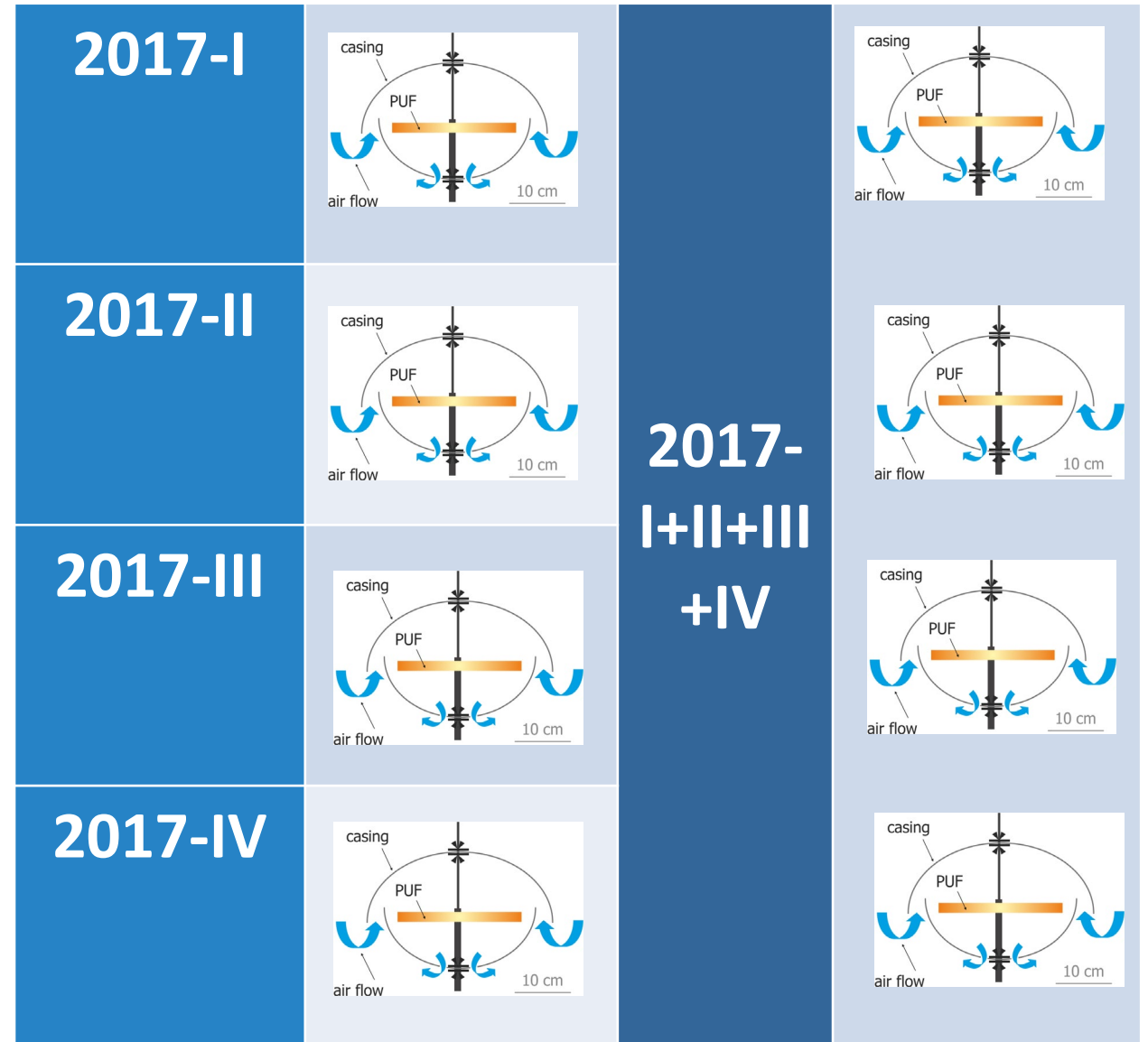
Samples - Reporting

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

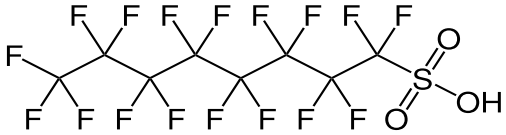

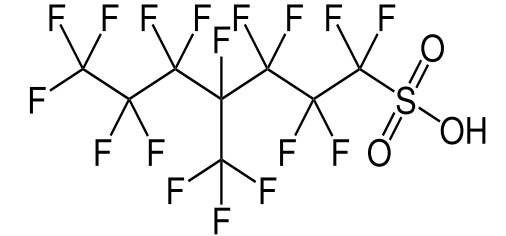
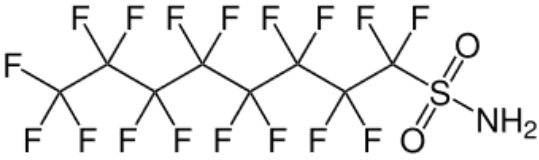
PD_Code	Range: Inhabitants <i>per</i> km ²
A	<24.9999
B	>25-<99.99
C	>100-<499.9
D	>500-<999.99
E	>1,000-<10,000
F	>10,000

PAS/PUF Results - PFAS

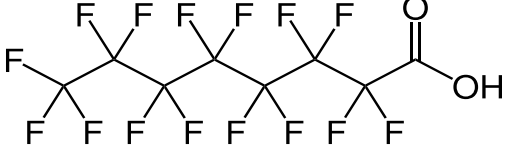
B. Across All Projects

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

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%)

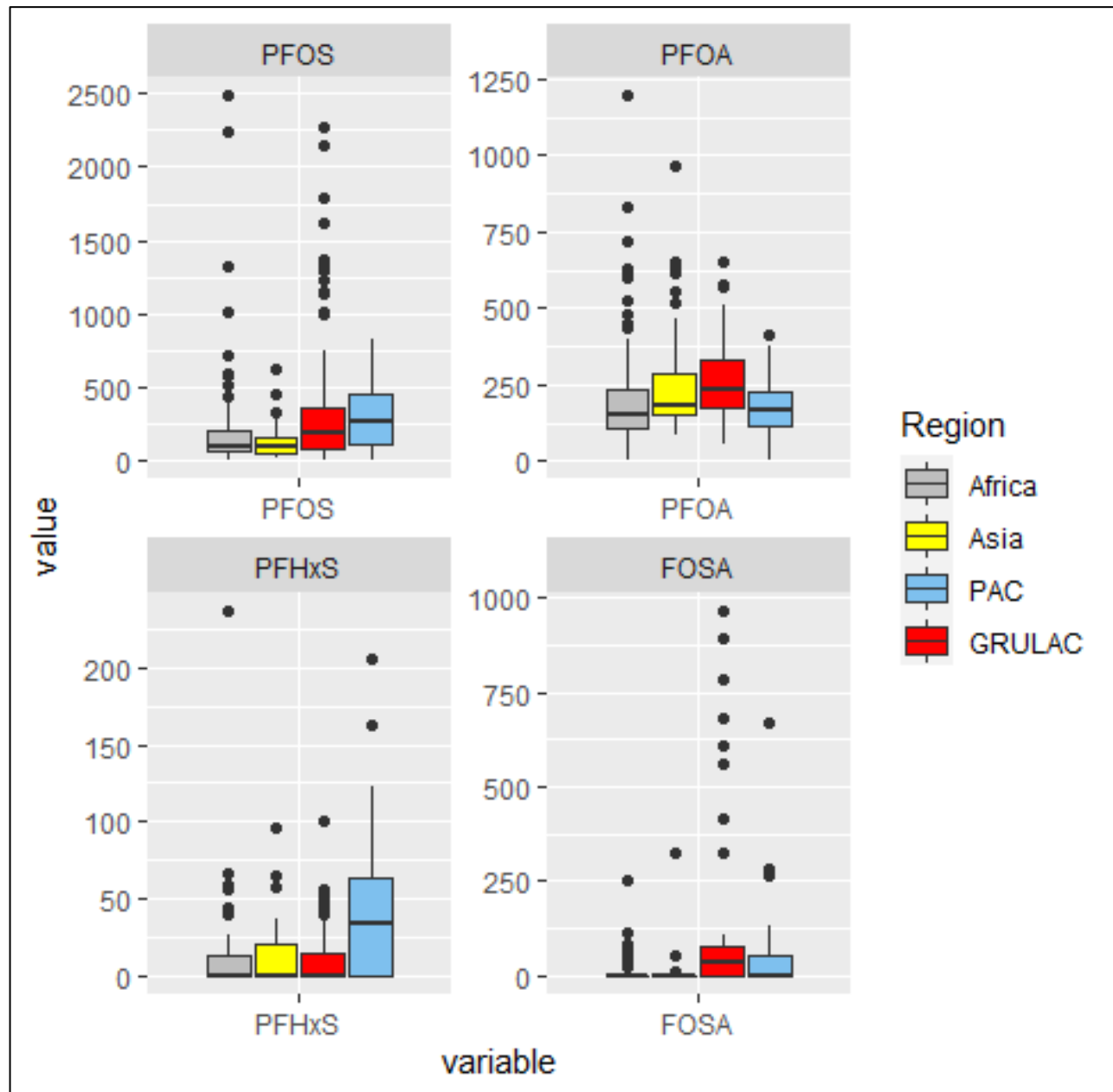
Summary results PAS/PUFs for PFAS (without outliers)

	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%)

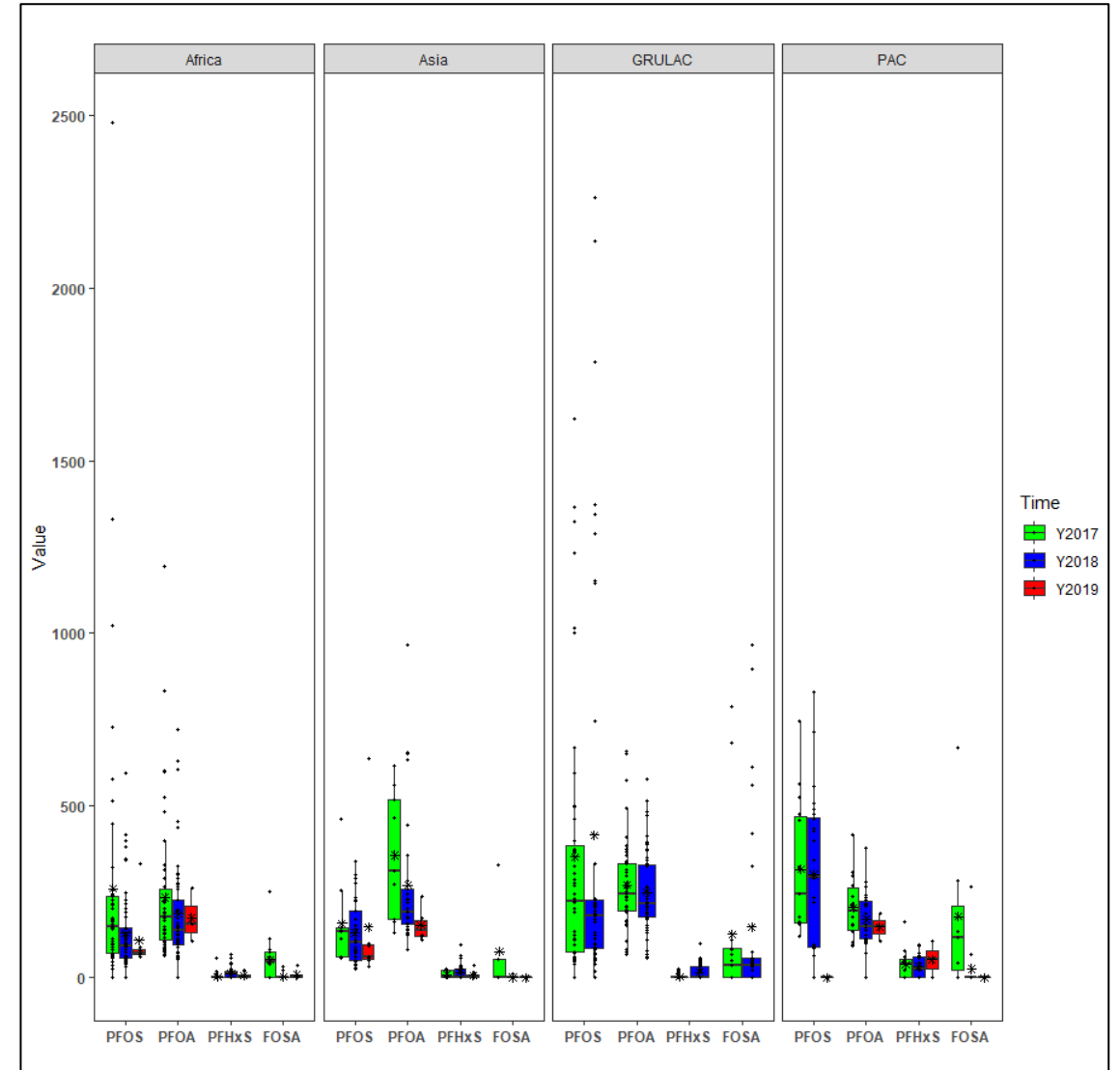
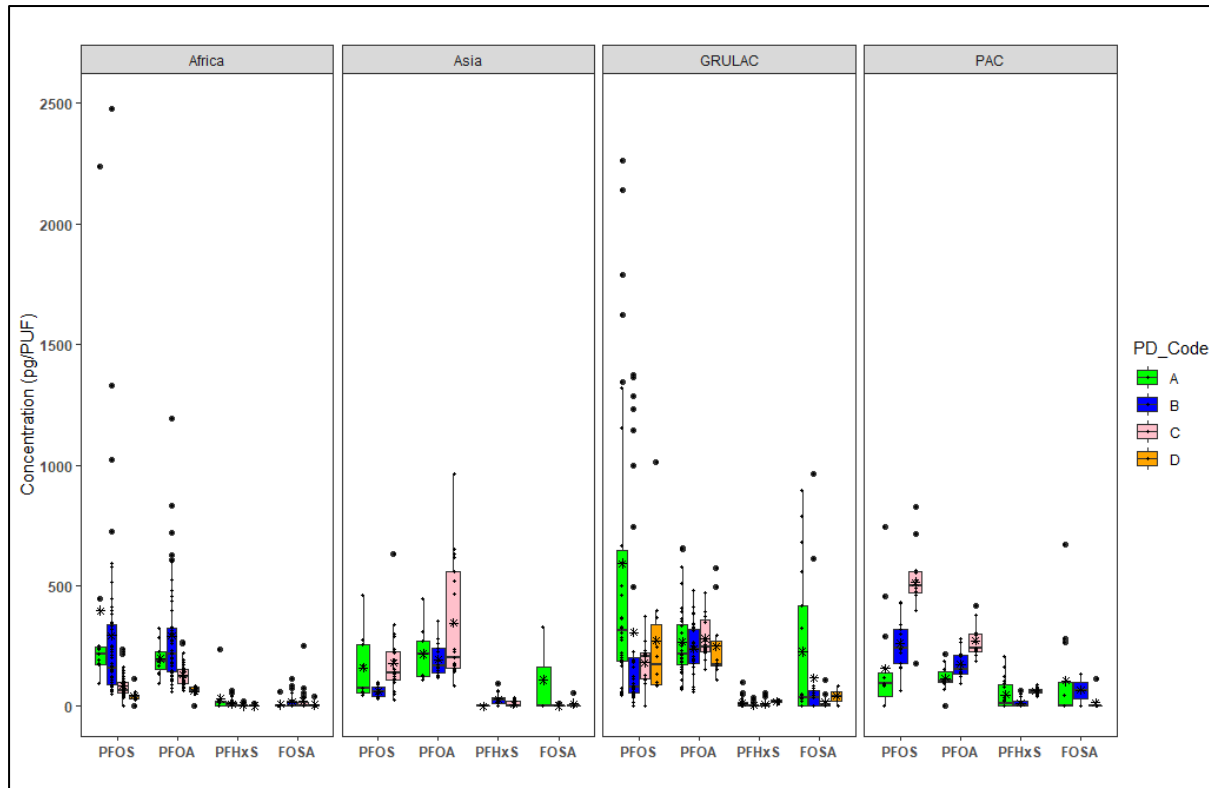
PAS/PUFs

Air (n=309)

Values in pg/PUF and
3 months exposure

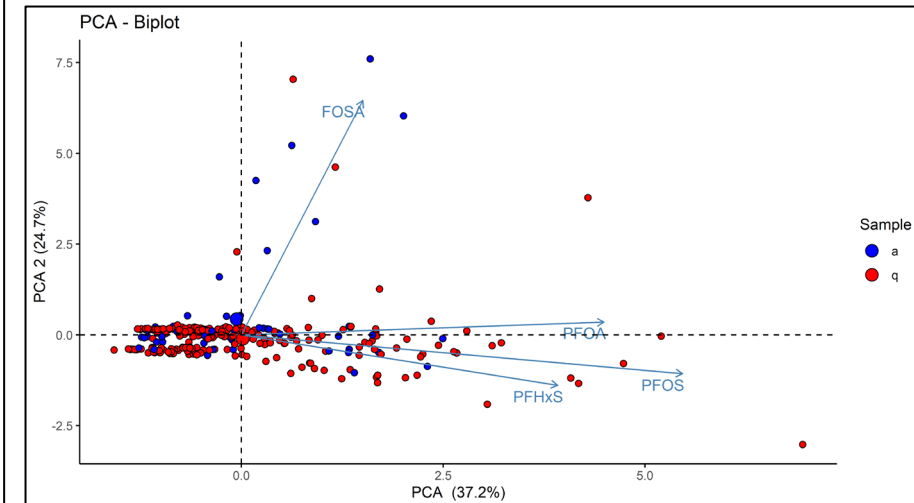
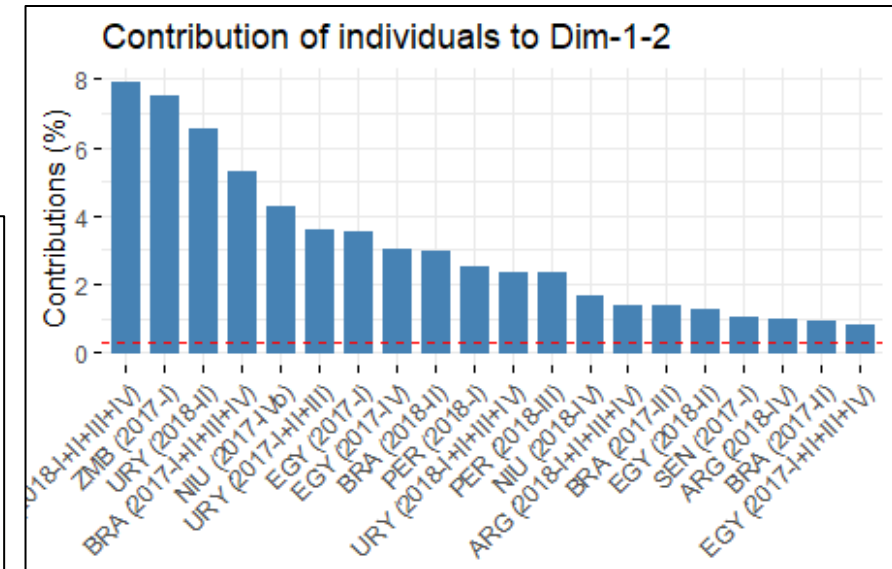
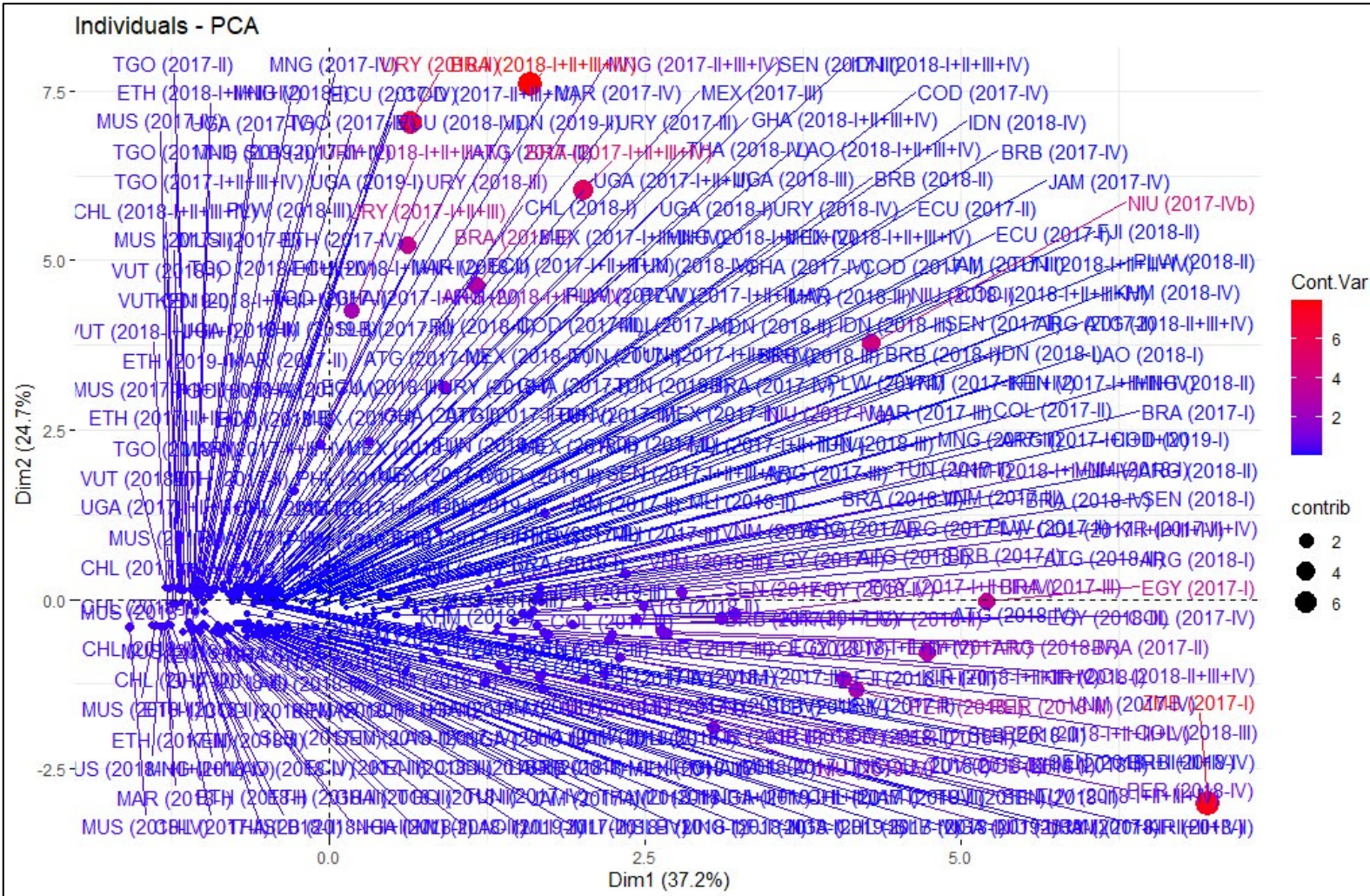


Overview PFAS by year and PD (n=309)

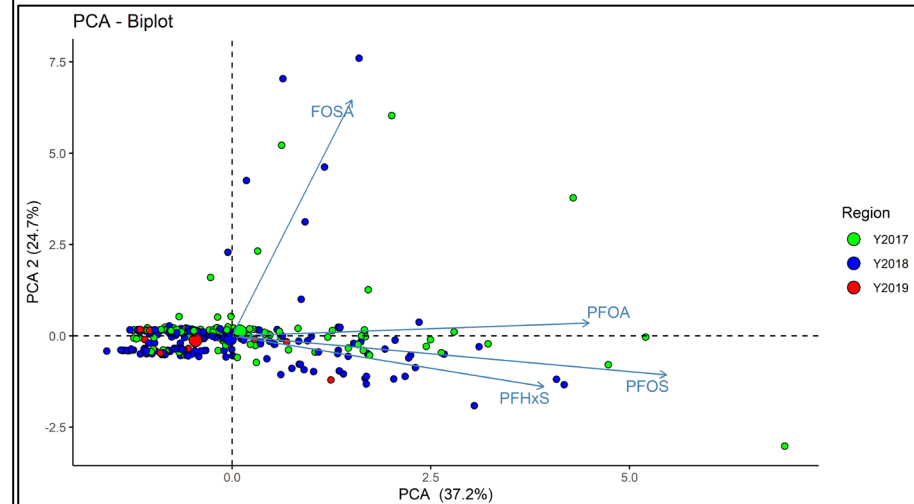
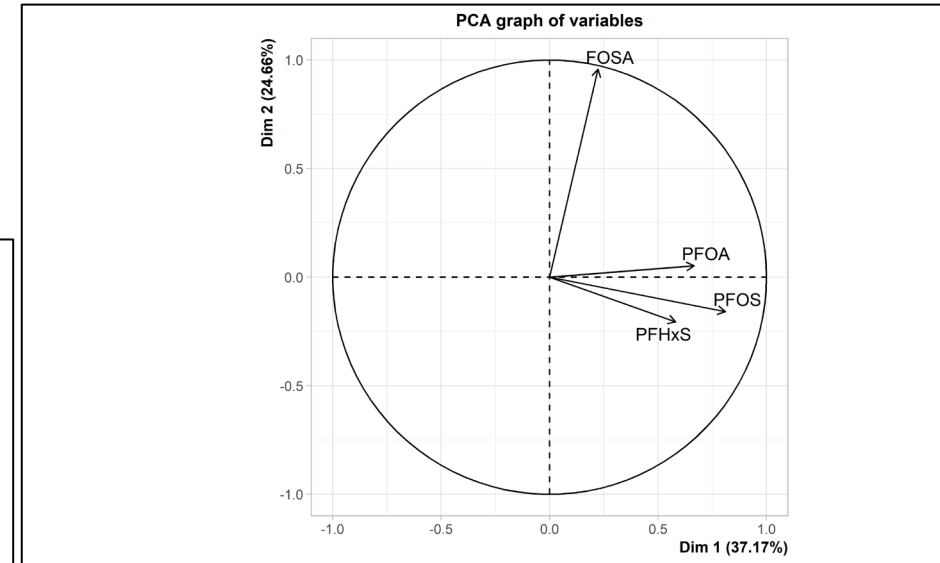
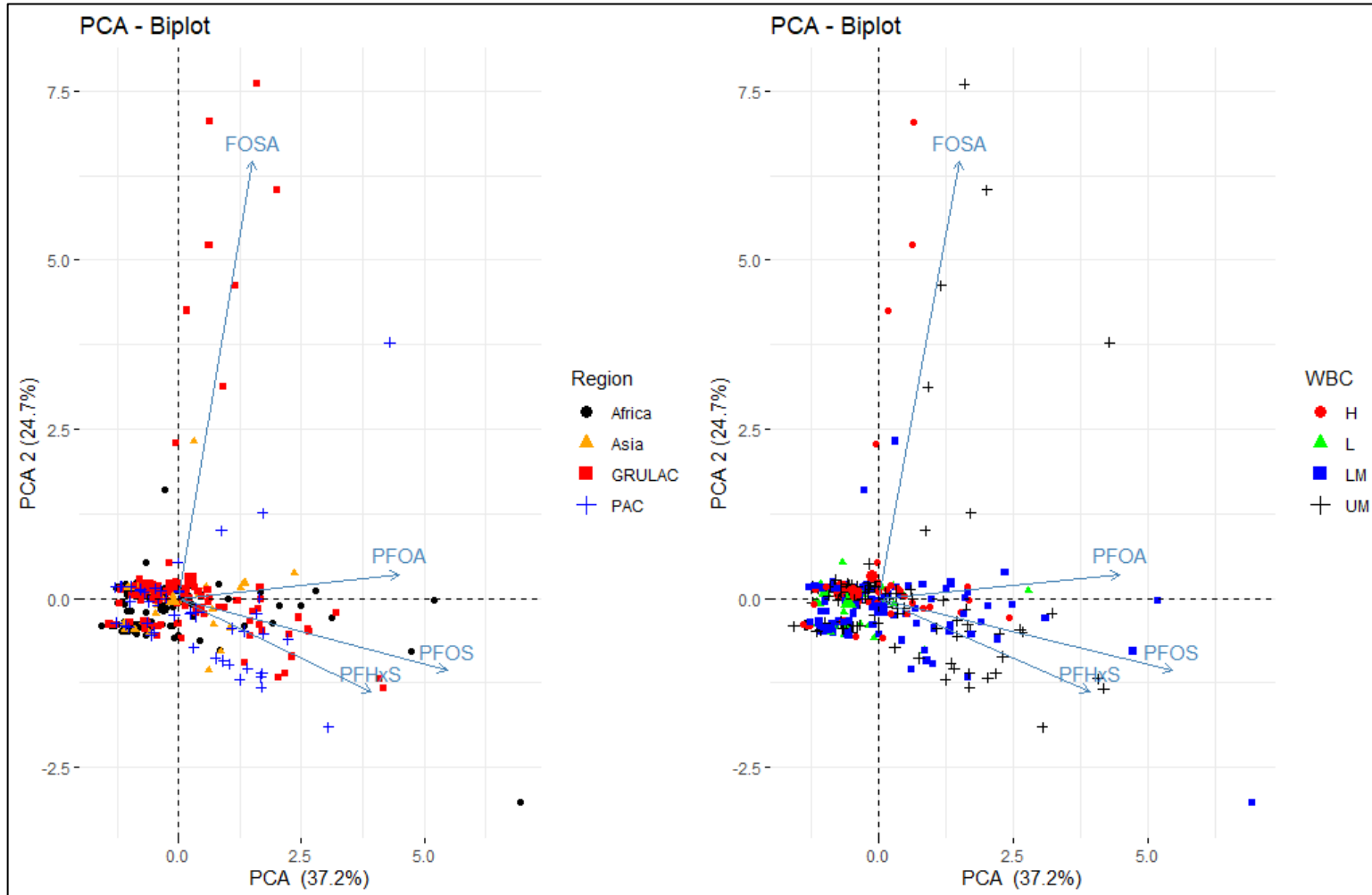


Values in pg/PUF and
3 months exposure

PCA biplot for region (n=309)



PCA biplots



PFAS Results

B.3 GRULAC Region

Country name	ISO-3	Project Region	WBC 2017	WBC 2018	PD 2017	PD 2018
Antigua and Barbuda	ATG	GRULAC	H	H	C	C
Argentina	ARG	GRULAC	H	UM	A	A
Barbados	BRB	GRULAC	H	H	D	D
Brazil	BRA	GRULAC	UM	UM	A	B
Chile	CHL	GRULAC	H	H	A	B
Colombia	COL	GRULAC	UM	UM	B	B
Ecuador	ECU	GRULAC	UM	UM	B	B
Jamaica	JAM	GRULAC	UM	UM	C	C
Mexico	MEX	GRULAC	UM	UM	B	B
Peru	PER	GRULAC	UM	UM	A	A
Uruguay	URY	GRULAC	H	H	A	A

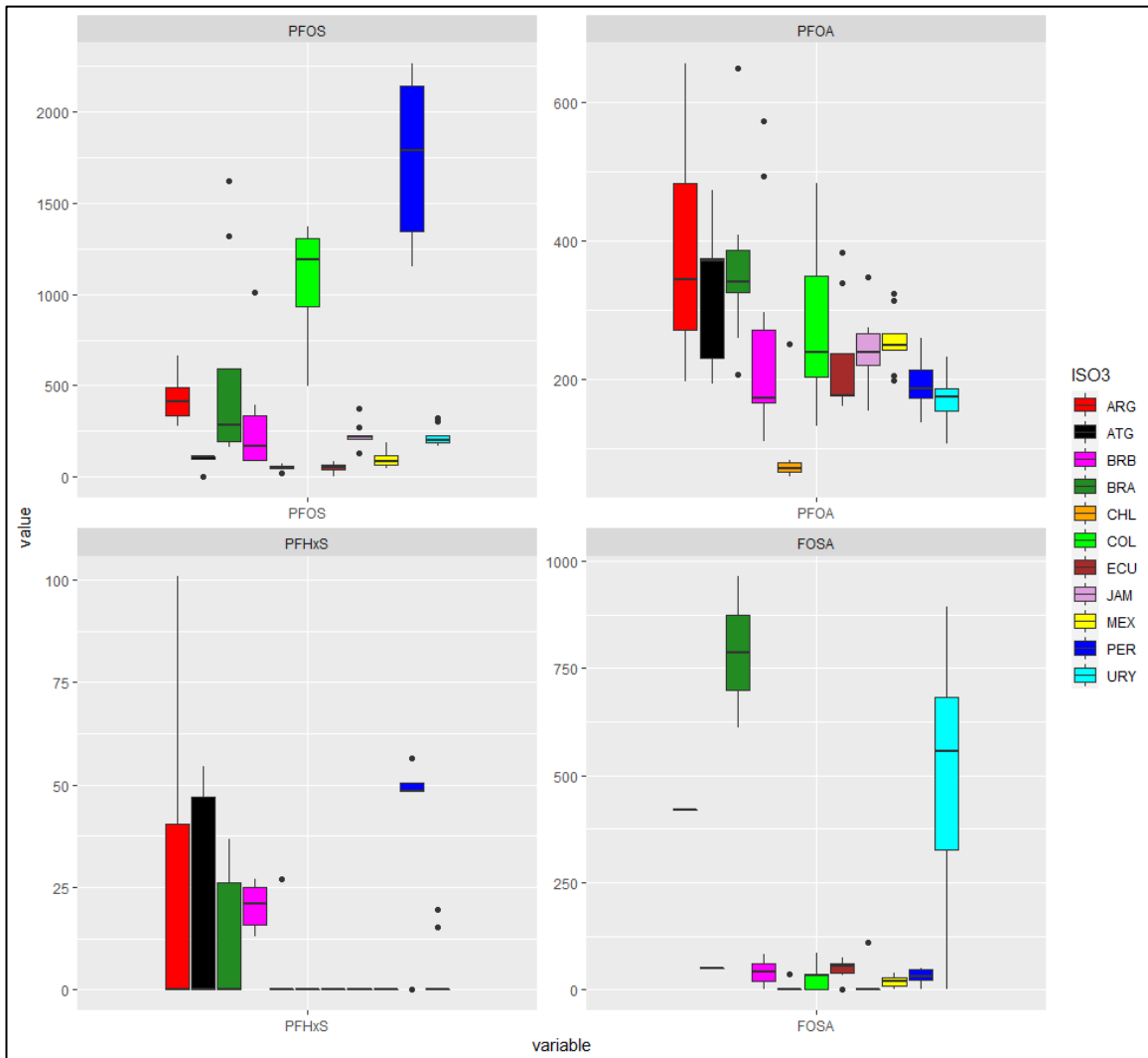
Number of samples and classification

	ARG (N=10)	ATG (N=9)	BRA (N=10)	BRB (N=10)	CHL (N=10)	COL (N=9)	ECU (N=10)	JAM (N=10)	MEX (N=10)	PER (N=5)	URY (N=9)	Overall (N=102)
YYYY												
Y2017	5 (50.0%)	4 (44.4%)	5 (50.0%)	5 (50.0%)	5 (50.0%)	5 (55.6%)	5 (50.0%)	5 (50.0%)	5 (50.0%)	0 (0%)	4 (44.4%)	48 (47.1%)
Y2018	5 (50.0%)	5 (55.6%)	5 (50.0%)	5 (50.0%)	5 (50.0%)	4 (44.4%)	5 (50.0%)	5 (50.0%)	5 (50.0%)	5 (100%)	5 (55.6%)	54 (52.9%)
WBC												
H	5 (50.0%)	9 (100%)	0 (0%)	10 (100%)	10 (100%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	9 (100%)	43 (42.2%)
UM	5 (50.0%)	0 (0%)	10 (100%)	0 (0%)	0 (0%)	9 (100%)	10 (100%)	10 (100%)	10 (100%)	5 (100%)	0 (0%)	59 (57.8%)
PD_Code												
A	10 (100%)	0 (0%)	5 (50.0%)	0 (0%)	5 (50.0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	5 (100%)	9 (100%)	34 (33.3%)
C	0 (0%)	9 (100%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	10 (100%)	0 (0%)	0 (0%)	0 (0%)	19 (18.6%)
B	0 (0%)	0 (0%)	5 (50.0%)	0 (0%)	5 (50.0%)	9 (100%)	10 (100%)	0 (0%)	10 (100%)	0 (0%)	0 (0%)	39 (38.2%)
D	0 (0%)	0 (0%)	0 (0%)	10 (100%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	10 (9.8%)
Sample												
a	2 (20.0%)	2 (22.2%)	2 (20.0%)	2 (20.0%)	2 (20.0%)	2 (22.2%)	2 (20.0%)	2 (20.0%)	2 (20.0%)	1 (20.0%)	2 (22.2%)	21 (20.6%)
q	8 (80.0%)	7 (77.8%)	8 (80.0%)	8 (80.0%)	8 (80.0%)	7 (77.8%)	8 (80.0%)	8 (80.0%)	8 (80.0%)	4 (80.0%)	7 (77.8%)	81 (79.4%)

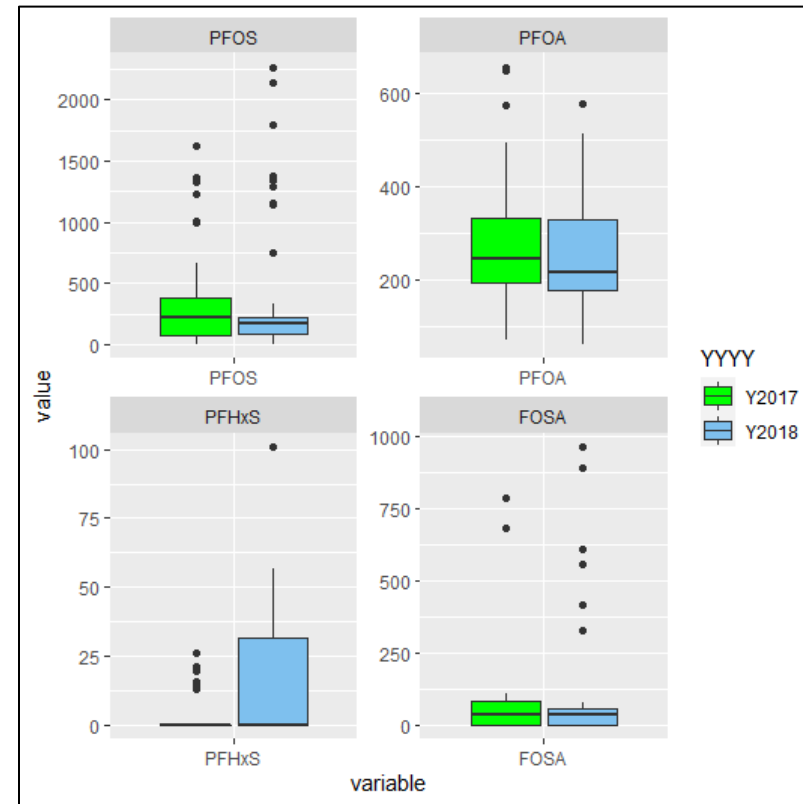
Summary of quantitative results

	ARG (N=10)	ATG (N=9)	BRA (N=10)	BRB (N=10)	CHL (N=10)	COL (N=9)	ECU (N=10)	JAM (N=10)	MEX (N=10)	PER (N=5)	URY (N=9)	Overall (N=102)
PFOS												
Mean (SD)	433 (141)	86.6 (48.9)	550 (544)	272 (285)	52.6 (16.8)	1080 (316)	47.4 (28.6)	228 (60.7)	96.6 (42.9)	1740 (484)	222 (54.5)	376 (497)
Median [Min, Max]	414 [276, 666]	111 [0, 115]	286 [162, 1620]	171 [86.3, 1010]	55.4 [18.7, 74.9]	1190 [495, 1370]	56.1 [0, 83.2]	219 [131, 372]	88.8 [47.6, 190]	1790 [1150, 2260]	202 [170, 323]	192 [0, 2260]
Missing	4 (40.0%)	4 (44.4%)	1 (10.0%)	0 (0%)	1 (10.0%)	1 (11.1%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	11 (10.8%)
PFOA												
Mean (SD)	380 (155)	319 (97.2)	364 (123)	250 (157)	93.2 (64.3)	279 (119)	222 (82.5)	245 (49.6)	256 (42.0)	194 (45.7)	172 (35.7)	257 (125)
Median [Min, Max]	343 [197, 655]	371 [194, 472]	341 [207, 649]	173 [110, 572]	72.1 [58.9, 251]	239 [133, 482]	177 [162, 383]	240 [155, 348]	249 [199, 324]	187 [138, 260]	174 [108, 231]	233 [58.9, 655]
Missing	0 (0%)	0 (0%)	1 (10.0%)	0 (0%)	2 (20.0%)	1 (11.1%)	1 (10.0%)	0 (0%)	1 (10.0%)	0 (0%)	0 (0%)	6 (5.9%)
PFHxS												
Mean (SD)	22.7 (34.2)	21.4 (25.7)	12.4 (15.6)	20.2 (5.16)	2.70 (8.55)	0 (0)	0 (0)	0 (0)	0 (0)	40.8 (23.0)	3.86 (7.73)	9.99 (18.7)
Median [Min, Max]	0 [0, 101]	0 [0, 54.4]	0 [0, 36.7]	20.9 [13.1, 27.0]	0 [0, 27.0]	0 [0, 0]	0 [0, 0]	0 [0, 0]	0 [0, 0]	48.5 [0, 56.5]	0 [0, 19.5]	0 [0, 101]
Missing	0 (0%)	0 (0%)	1 (10.0%)	0 (0%)	0 (0%)	1 (11.1%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	2 (2.0%)
FOSA												
Mean (SD)	419 (NA)	49.9 (NA)	787 (177)	41.5 (58.7)	5.29 (14.0)	31.7 (35.5)	47.8 (25.1)	15.8 (41.7)	19.1 (27.1)	30.3 (20.2)	492 (343)	138 (260)
Median [Min, Max]	419 [419, 419]	49.9 [49.9, 49.9]	786 [611, 964]	41.5 [0, 83.0]	0 [0, 37.0]	34.9 [0, 86.3]	55.4 [0, 75.9]	0 [0, 110]	19.1 [0, 38.3]	31.4 [0, 48.9]	558 [0, 894]	34.9 [0, 964]
Missing	9 (90.0%)	8 (88.9%)	7 (70.0%)	8 (80.0%)	3 (30.0%)	4 (44.4%)	3 (30.0%)	3 (30.0%)	8 (80.0%)	0 (0%)	4 (44.4%)	57 (55.9%)

Country

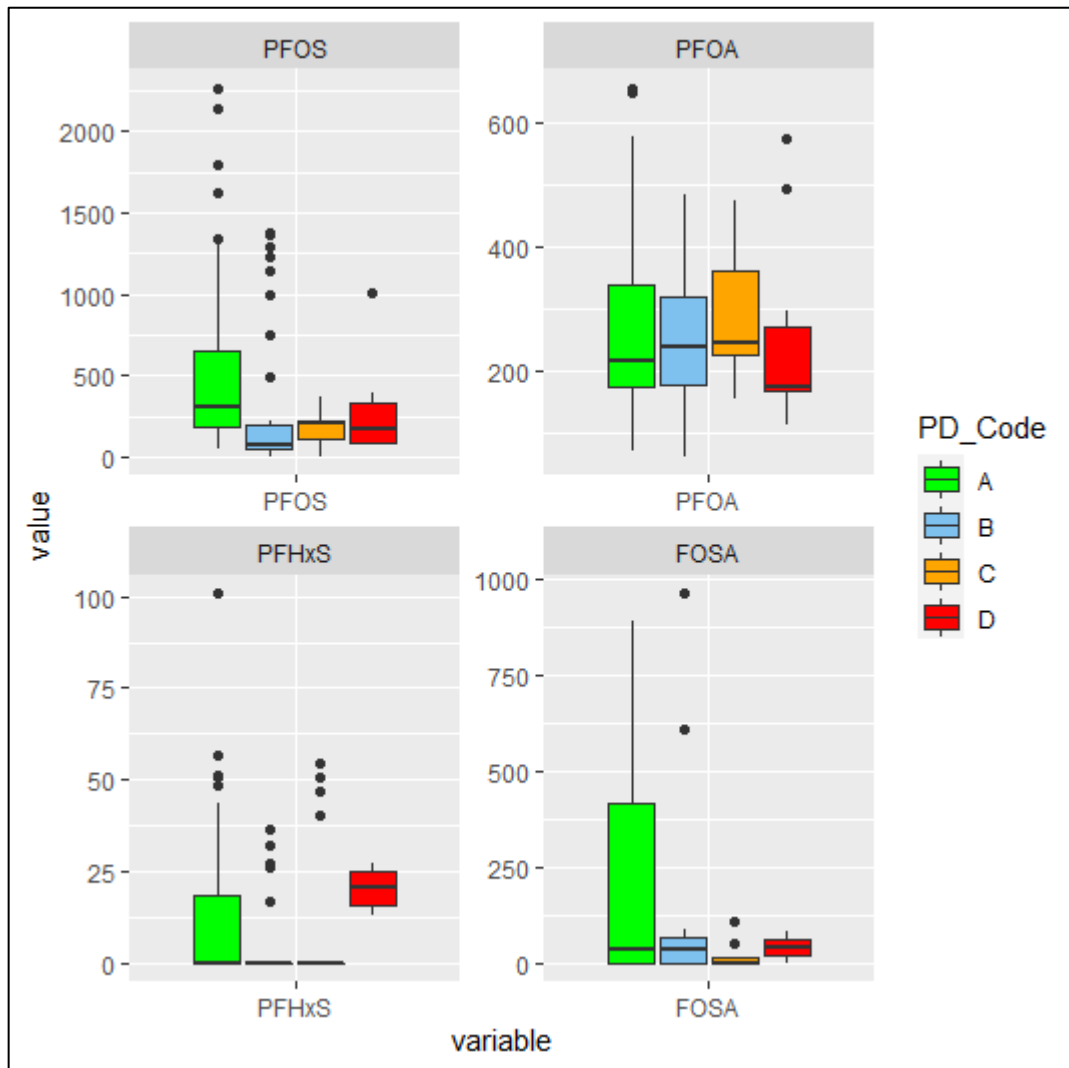


Sampling year

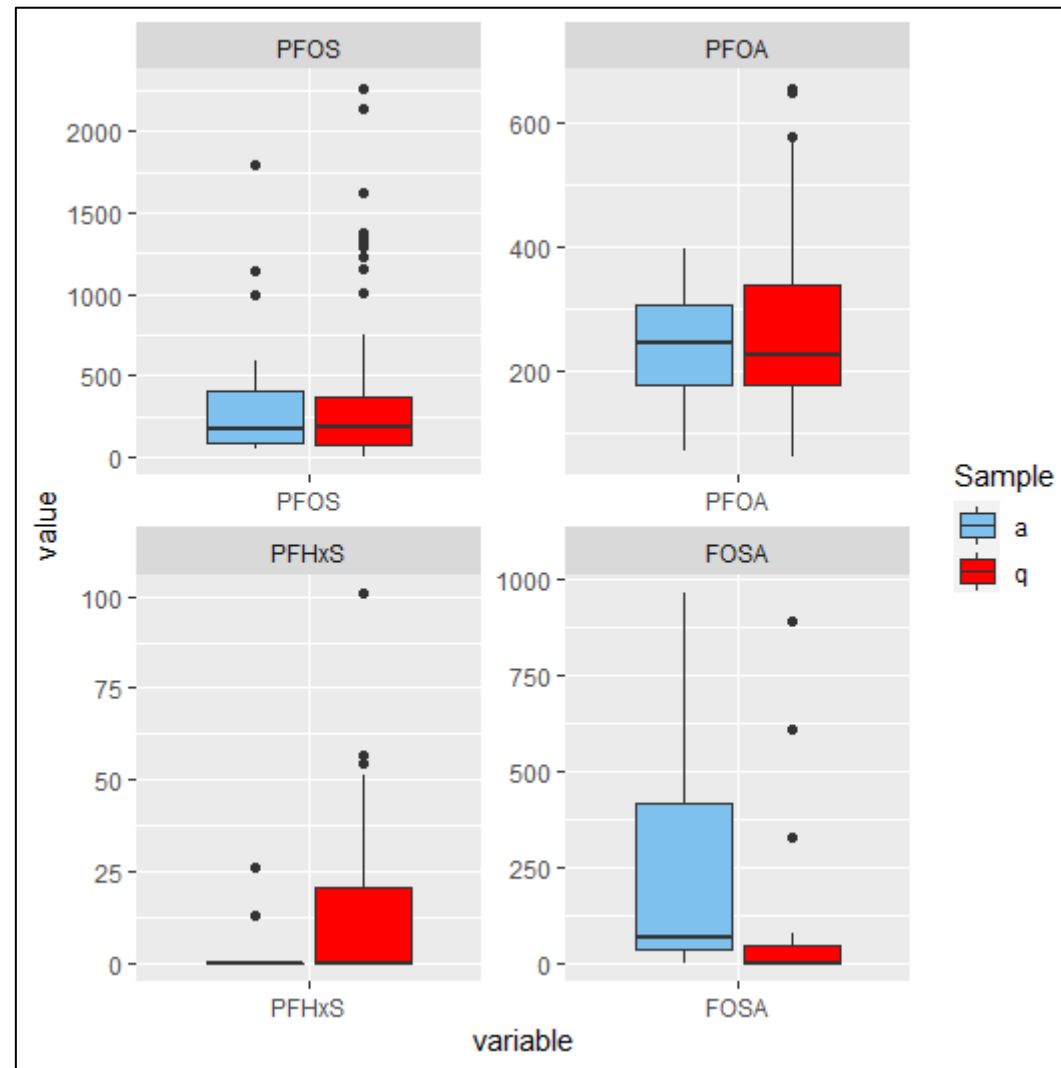


- More narrow range for PFOA than PFOS
- PER: only 2018; highest PFOS
- ARG: narrow for PFOS+PFOA and between years

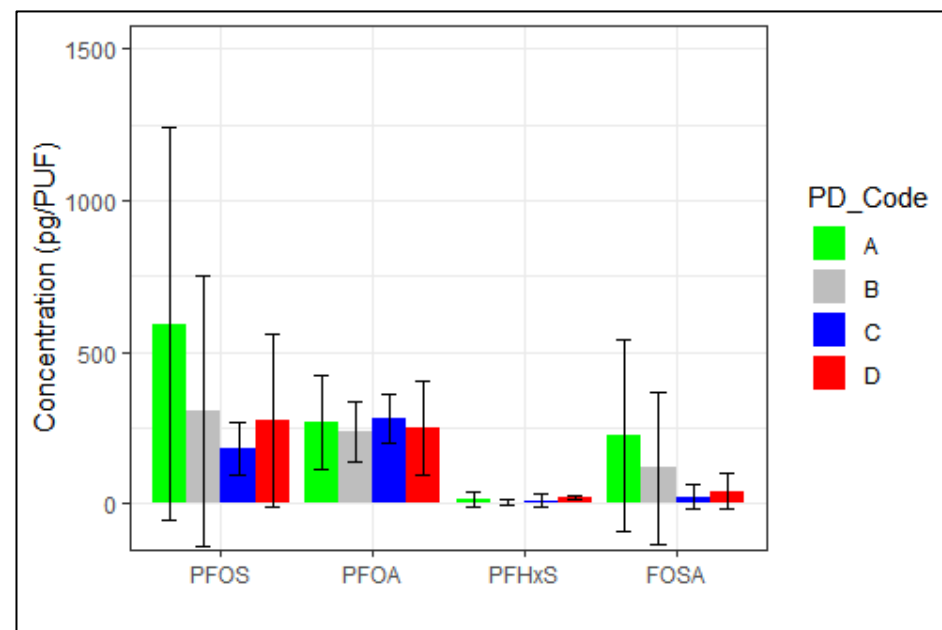
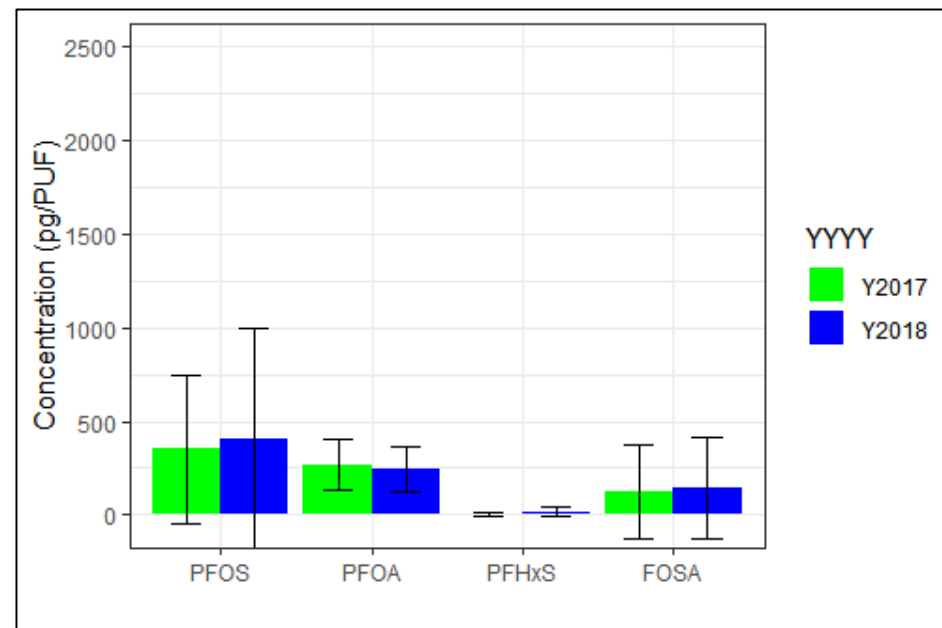
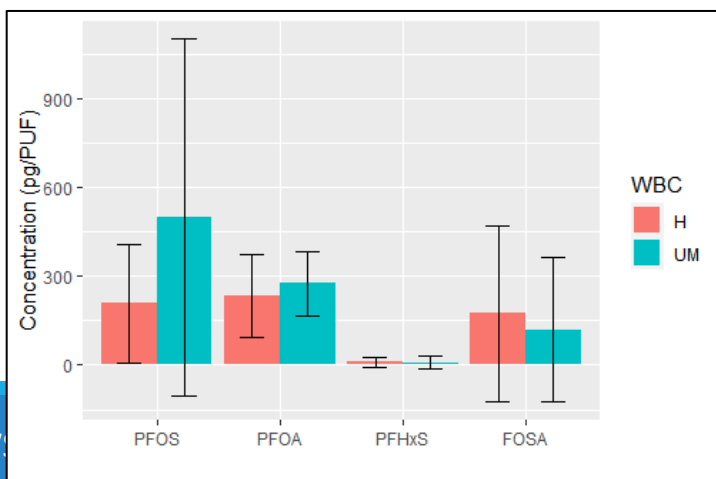
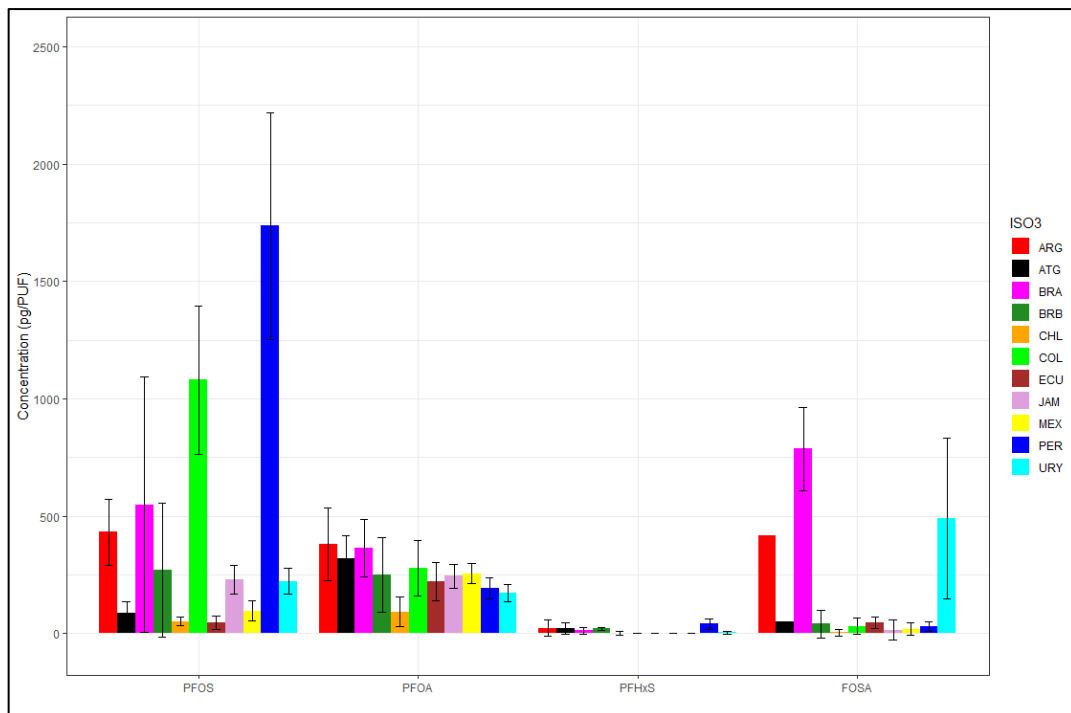
Population density



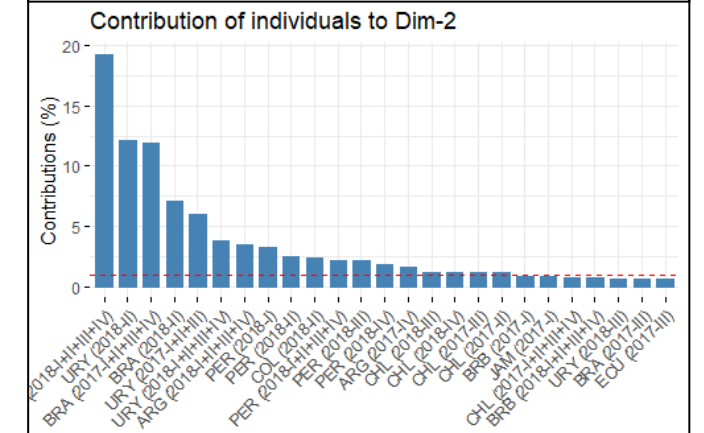
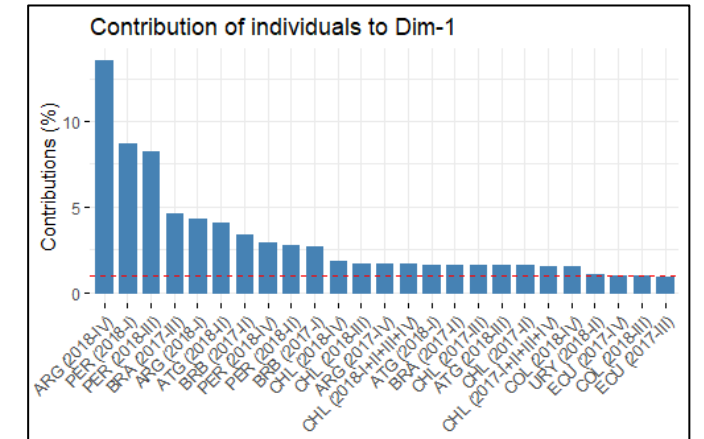
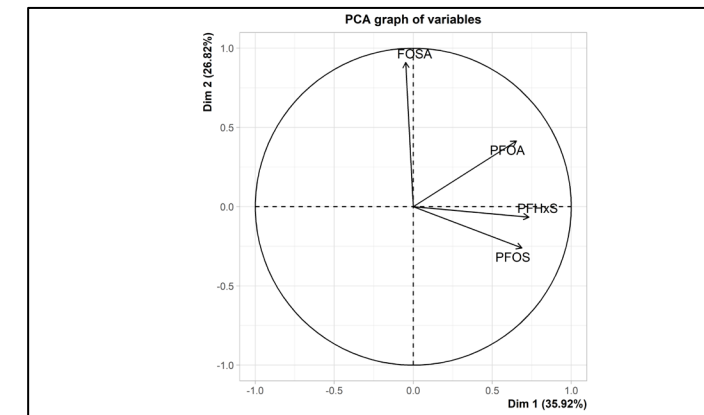
Sample type (quarterly vs. annual)



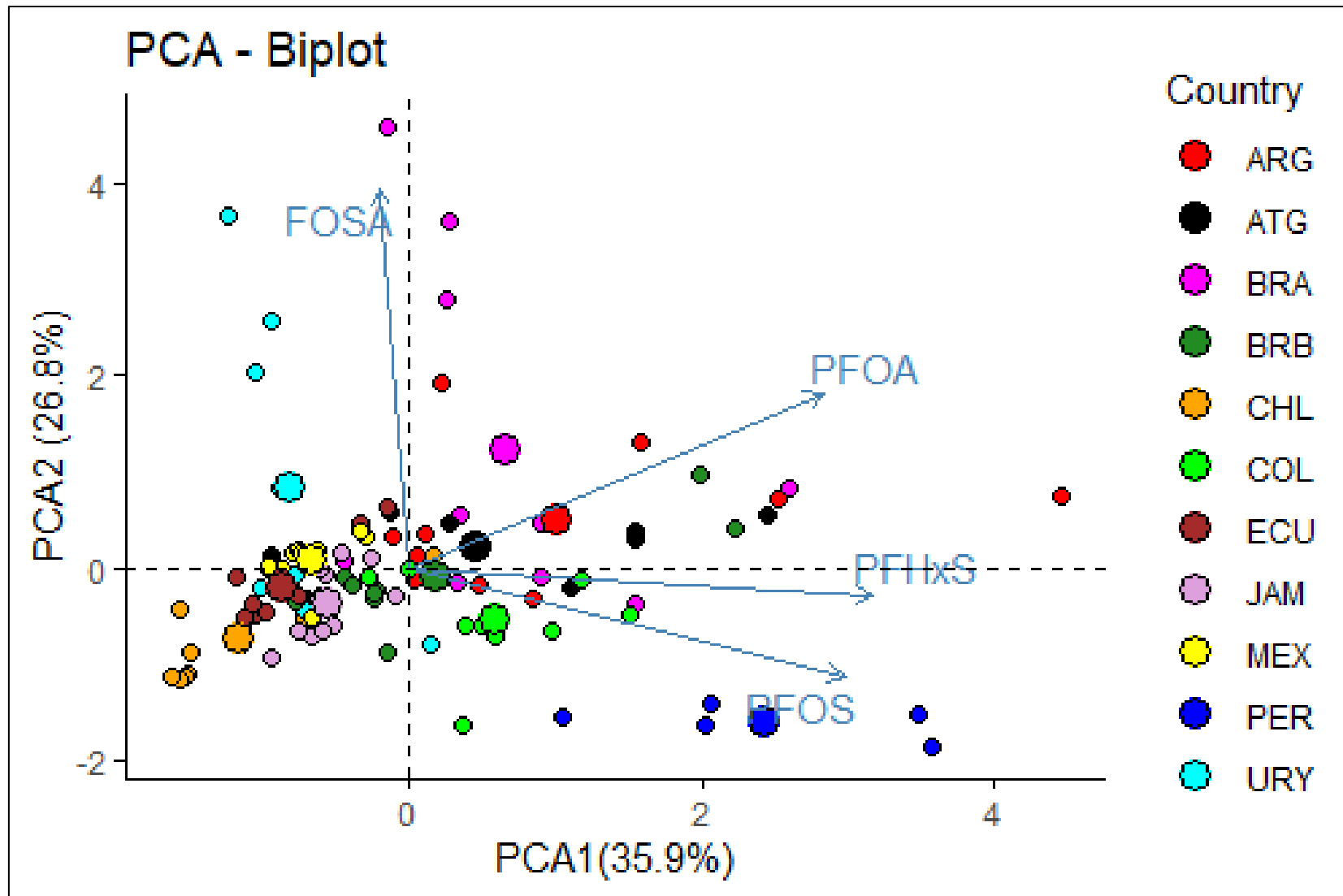
Mean values and SDs



PCA, PFAS in air GRULAC



PCA, by sample and country



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Thank you !