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Regional Report

Continuing Regional Support for the POPs Global Monitoring Plan under the Stockholm Convention in the Pacific Islands Region

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ABBREVIATIONS

CEE	Central and Eastern Europe
DDT	Dichlorodiphenyltrichloroethane
GEF	Global Environment Facility
GMP	Global monitoring plan
GRULAC	Group of Latin America and the Caribbean
HCH	Hexachlorocyclohexane
HBB	Hexabromobiphenyl
HBCD	Hexabromocyclododecane
PAS	Passive air sampler(s)
PBDE	Polybrominated diphenylether(s)
PCB	Polychlorinated biphenyl(s)
PCDD	Polychlorinated dibenzodioxins
PCDF	Polychlorinated dibenzofurans
PFAS	Perfluororoalkane substances
PFHxS	Perfluorohexanesulfonic acid
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctanesulfonic acid
PUF	Polyurethane foam
TEF	Toxicity equivalency factor
TEQ	Toxic equivalent
UN	United Nations
UNEP	United Nations Environment Programme
WBC	World Bank classification (of income groups)
WEOG	Western European and Other Groups
WHO	World Health Organization

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Introduction

Photo: ©Pexels / Tom Fisk

1. INTRODUCTION

Persistent organic pollutants (POPs) are characterized by certain toxic properties which include resistance to degradation in the environment, bioaccumulation across food chains and long-range transportation though air, water currents or migratory species (United Nations Environment Programme [UNEP] and Secretariat of the Stockholm Convention 2017). There are gender and age-differentiated windows of susceptibility and exposure to these harmful chemicals. Men and women, and children differ in their physiological susceptibility to the effects of exposure to hazardous chemicals, and different social roles related to gender, age and socioeconomic status can affect exposure to POPs (UNEP 2019a). For example, pregnancy, and lactation are periods of susceptibility for women and children where the transfer of POPs can occur (Secretariat of the Strategic Approach to International Chemicals Management 2018).

This report addresses activities and results in support of the global monitoring plan (GMP) as stipulated by the Stockholm Convention on Persistent Organic Pollutants (POPs) and coordinated by the United Nations Environment Programme (UNEP). The report covers the period of the UNEP/GEF GMP2 project implemented for nine countries in the Pacific Islands region (UNEP 2015a); it does not include the seven countries in the Asian project, which had a self-standing project and final regional report (UNEP 2015b; UNEP 2024a). The report covers the time between 2016 and 2021.

Activities related to the two rounds of interlaboratory assessments, are referred to in a separate report (UNEP 2023a).

1.1. Compounds to be monitored

The UNEP/GEF GMP2 projects from the onset had the POPs listed until 2013 included (see Table 1, upper part). At the mid-term workshops in 2017, it was agreed with the participating countries and the expert laboratories to expand the spectrum to all POPs listed. In addition, agreement was reached to also include perfluorohexanesulfonic acid (PFHxS), which is recommended for listing by the POPs review committee (Secretariat of the Stockholm Convention 2019a) and listed in 2022 at the tenth meeting of the Conference of the parties (see lower part of Table 1) (Secretariat of the Stockholm Convention 2022).

Table 1: Recommended analytes

COP	POPs or POPs group	Recommended analytes
Initial POPs	Aldrin	Aldrin
	Chlordane	cis- and trans-chlordane; and cis- and trans-nonachlor, oxychlordane
	Dichlorodiphenyltrichloroethane (DDT)	4,4'-DDT, 2,4'-DDT and 4,4'-DDE, 2,4'-DDE, 4,4'-DDD, 2,4'-DDD
	Dieldrin	Dieldrin
	Endrin	Endrin
	Hexachlorobenzene	HCB
	Heptachlor	Heptachlor and heptachlorepoxide
	Mirex	Mirex
	PCB	ΣPCB_6 (6 congeners): 28, 52, 101, 138, 153, and 180
		PCB with TEFs (12 congeners): 77, 81, 105, 114, 118, 123, 126, 156, 157, 167, 169, and 189
	PCDD/PCDF	2,3,7,8-substituted PCD/PCDF (17 congeners)
	Toxaphene	Congeners P26, P50, P62
COP-4	Chlordecone	Chlordecone
	alpha-hexachloro-cyclohexane	α–HCH
	beta-hexachloro-cyclohexane	β–HCH
	Lindane	γ–HCH
	Hexabromobiphenyl	PBB 153
	Pentachlorobenzene	PeCBz
	Tetra- and pentabromo-diphenyl ether *	PBDE 47, 99, 153, 154, 175/183 (co-eluting), Optional: PBDE 17, 28, 100
	Hexa- and heptabromo-diphenyl ether **	
	Perfluorooctane sulfonic acid	PFOS (linear and branched PFOS, SPFOS) for air, precursor compounds: FOSA, NMeFOSA, NEtFOSA, NMeFOSE, NEtFOSE)
COP-5	Endosulfan	α-, β-endosulfan; and endosulfan sulfate
COP-6	Hexabromocyclododecane	α-HBCD, β-HBCD, γ-HBCD
COP-7	Hexachlorobutadiene	HCBD
	Polychlorinated naphthalenes (PCN)	[PCN]
	Pentachlorophenol	[PCP, PCA]
COP-8	Short-chain chlorinated paraffins (SCCP)	[SCCP]
	Decabromodiphenyl ether	PBDE 209
COP-9	Dicofol	Dicofol
	Perfluorooctanoic acid	PFOA
COP-10	Perfluorohexanesulfonic acid	PFHxS

* commercial pentabromodiphenyl ether, c-penta BDE

** commercial octabromodiphenyl ether, c-octa BDE

Note: For substance groups in square brackets (status as of 2019), no decision has been made as to the recommended analytes to be alyzed.

1.2. Matrices to be sampled

Passive air samplers (PAS) have been developed as simple and cost-effective and PAS equipped with polyurethane foam (PUF) disks (Shoeib and Harner 2002; Herkert, Martinez, and Hornbuckle 2016) or XAD resins (Wania *et al*. 2003) have been widely applied to measure and assess atmospheric concentrations of POPs, due to their capacity to retain POPs at low cost and ease of handling. The sorbing matrix (PUF) is usually installed in protective chamber, which can be either formed like a dome or a cylinder (Shoeib and Harner 2002). This protective chamber used to protect the sorbent from the deposition of the large particle, sunlight, precipitation, and help to reduce the impact of wind speed on the sampling rate.

Among the core matrices to evaluate changes in POPs concentrations over time, human milk and human blood were recommended to assess human exposure. In the UNEP-coordinated projects, human milk was chosen to be analyzed for all POPs listed in the annexes of the Convention. The biomonitoring component of the GMP has been put in place by UNEP in coordination with the World Health Organization (WHO) (Secretariat of the Stockholm Convention 2013). Due to inherent persistence and bioaccumulation of POPs, the biomonitoring samples should be collected from primiparae, *i.e.,* mothers having their first child.

In order to promote reliability and comparability of results, samples were collected by the participating countries following a comprehensive protocol originally developed by WHO and modified by UNEP to allow analysis for all POPs (UNEP 2017a). Participating countries were encouraged to adhere as closely as possible to the protocol, which provides guidance on the number and type of samples, selection of donors, collection, storage and pooling of samples, and shipping of samples to the State Institute for Chemical and Veterinary Analysis of Food (Chemisches und Veterinäruntersuchungsamt, CVUA), Freiburg, Germany, contracted by UNEP. For each sample, national approval was obtained before sampling, following the general ethical guidelines for studies involving human subjects by the WHO (WHO 2011). The identity of the mothers was not disclosed. In brief, one national pool as a representative sample should be prepared by collecting 50 mL of breast milk from 50 mothers for up to 50 million citizens. The most important criterion is that the donating mother should be *primiparae*; all other criteria were less important and included that the donor should be (i) healthy, (ii) exclusively breastfeeding one child (no twins), and (iii) residing in the area since about five years. The recommended time for taking the sample should be 3-8 weeks after delivery (UNEP 2017a).

To avoid contamination of the sample, CVUA sent 100 mL pre-cleaned glass bottles to each participating country to collect the breast milk from individual mothers. In addition, a 2 L pre-cleaned glass bottle was provided to prepare the national pool. For the national pool, 25 mL human milk (if available) from each mother was placed into glass bottle, kept in a fridge or freezer until shipment to the central laboratory in Freiburg. After arrival, CVUA took one aliquot of 10 mL and shipped to MTM Research Centre at Örebro University for PFAS analysis. The results are reported *per* national pool or national sub-pool in the case of Niue and Germany.

The GMP defined water as a core matrix to evaluate changes over time caused by Party action to eliminate POPs according to the goals of the Stockholm Convention (Fiedler *et al*. 2019; Fiedler *et al*. 2020a) for PFOS and PFOA; not for the other POPs. The GMP guidance document (UNEP 2021) already included PFHxS. The aim of the UNEP-coordinated GMP2 projects was to test the suitability of the guidance document established for water sampling (Weiss *et al*. 2015) and to investigate the levels of PFOS, PFOA and PFHxS in surface water samples collected from developing countries in Africa, Asia-Pacific, and Group of Latin America and Caribbean (GRULAC) countries.

To summarize, the matrices for POPs analysis include the following core matrices:

1	Ambient air:	for all POPs (including PFOS precursors and PBDE 17 and PBDE 28)
2	Human milk:	All POPs
3	Water:	PFOS, PFOA and PFHxS

This report covers the core matrices only and does not present other matrices albeit analyzed by the expert laboratories and following general guidance produced under the UNEP/GEF GMP2 projects (UNEP 2017b). The sampling strategies followed national priorities to collect ‘samples of national interest’ but also had a strong capacity building component since the sampling strategy was built on having mirror samples; *i.e.* the same sample analyzed in an expert laboratory and in a national laboratory. For information, the national reports produced by the participating countries should be consulted.

SECTION 2

Characteristics of the participating countries

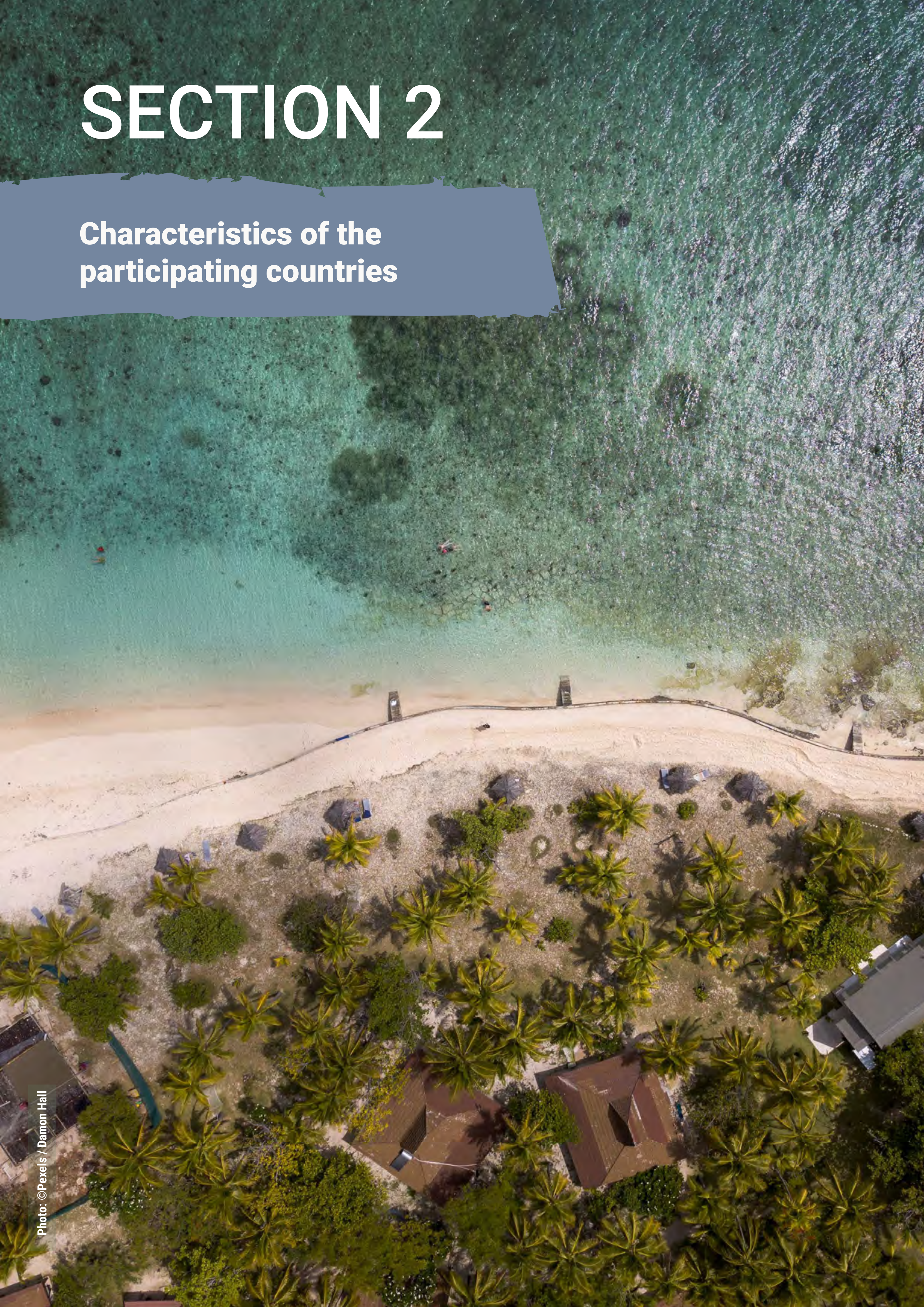


Photo: ©Pexels / Damon Hall

2. CHARACTERISTICS OF THE PARTICIPATING COUNTRIES

2.1. Global development indicators of participating countries

For the characterization of the economic situation in a country, the World Bank Classification (WBC) is used by defining the four income groups (L=low, LM=lower-middle, UM=upper-middle, H=high) as the gross national income (GNI) per capita purchasing power in US$ according to the Atlas methodology (World Bank n.d. a). Economically, Palau was a high income (H) country throughout the project period. Five countries (Fiji, Marshall Islands, Niue, Tuvalu and Samoa) were UM, and three countries were LM (Kiribati, Solomon Islands, and Vanuatu) (Table 2).

The countries in the Pacific Islands project differ largely as to population, although all of them with relatively small populations compared to global level, and population density, which is defined as population per square kilometer of land area (pop/km²). Niue, Solomon Islands and Vanuatu were the least densely populated countries (PD<25, having less than 25 inhabitants per km²) whereas Tuvalu was the most densely populated country and among the nine PACs (PD 330-2000) (World Bank n.d. b).

2.2. Assessment and visualization of results

All data were maintained in Microsoft Office 365 Excel®; statistical evaluations were made using R packages with R-Studio. The Kruskal-Wallis H test was used to determine if there are statistically significant differences between the independent variables and dependent variables. Post-hoc analysis was performed using the pairwise Wilcoxon test. Adjustment of the p-value was made using the Benjamini-Hochberg method. Significance level was set to p=0.05.

Table 2: WBC classifications of the Pacific Islands countries. GNI per capita purchasing power Population density (PD) for reference year: left=pop/km², right=PD Code

Country name	ISO-3	GNI 2017	WBC 2017	GNI 2018	WBC 2018	GNI 2019	WBC 2019
Fiji	FJI	12 370	UM	13 260	UM	13 090	UM
Kiribati	KIR	4 280	LM	4 290	LM	4 860	LM
Marshall Islands	MHL	4 770	UM	4 990	UM	5 190	UM
Niue	NIU	15 100	UM	15 800	UM	16 550	UM
Palau	PLW	18 910	H	19 430	H	19 130	H
Solomon Islands	SLB	2 610	LM	2 730	LM	2 740	LM
Tuvalu	TUV	5 570	UM	6 080	UM	6 160	UM
Vanuatu	VUT	3 090	LM	3 260	LM	3 530	LM
Samoa	WSM	6 290	UM	6 310	UM	6 620	UM

Country name	ISO-3	Population km² 2017	PD 2017	Population km² 2018	PD 2018	Population km² 2019	PD 2019
Fiji	FJI	48	PD 25-90	48	PD 25-90	49	PD 25-90
Kiribati	KIR	141	PD 90-200	143	PD 90-200	145	PD 90-200
Marshall Islands	MHL	323	PD 200-330	325	PD 200-330	327	PD 200-330
Niue	NIU	6	PD<25	6	PD<25	6	PD<25
Palau	PLW	39	PD 25-90	39	PD 25-90	39	PD 25-90
Samoa	WSM	69	PD 25-90	69	PD 25-90	70	PD 25-90
Solomon Islands	SLB	23	PD<25	23	PD<25	24	PD<25
Tuvalu	TUV	379	PD 330-2000	384	PD 330-2000	389	PD 330-2000
Vanuatu	VUT	23	PD<25	24	PD<25	25	PD<25

SECTION 3

National activities with respect to sampling and POPs analysis

Photo: ©Pexels / Mikhail Nilov

3. NATIONAL ACTIVITIES WITH RESPECT TO SAMPLING AND POPS ANALYSIS

3.1. Sampling

For the sampling at national level, standard operational procedure (SOP) documents were developed and made available in English, Spanish and French for the core matrices: air using passive samplers (UNEP 2017c), water (UNEP 2017d), and human milk (UNEP 2017a). A fourth SOP was developed for the national samples (UNEP 2017b), which are not included in this report but can be found in the national reports for this project.

3.1.1. Core matrix air with PAS/PUF

For the GMP2 projects, a similar approach was taken having pairs of PAS exposed at one site, each of them equipped with one pre-cleaned PUF to capture a specified group of POPs. *Per* site, a maximum of 12 PAS were set up whereby each PUF from PAS with odd numbers were shipped to the expert laboratories and PUFs from even-numbered PAS should be analyzed in a national laboratory. As a general rule, each PUF should be exposed for one season, *i.e.*, three months, and be analyzed for the respective POPs group. For dl-POPs and toxaphene, since analysis is complex and expensive and concentrations were expected to be low, four PUFs should be combined for one annual sample.

All countries will have at least the samplers (and analyses) highlighted. PAS 7 and PAS 8 are special cases and will be exposed only when there is a national dioxin laboratory. In such cases, the expert laboratory and the national laboratory both will analyse the PUFs on the quarterly basis.

The set-up of the PAS/PUFs at a sampling site is detailed in Table 3.

Table 3: Assignment of samplers, PUFs, and analytes according to laboratory per country

PAS	PUF*	Destination Laboratory	Group of chemicals for analysis	# of analyses per year
PAS 1	I, II, III, IV	Basic POPs pesticides in expert back-up laboratory	aldrin, dieldrin, endrin, chlordane, DDT, alpha, beta, and gamma-HCHs, heptachlor, mirex, HCB, pentachlorobenzene, endosulfan, toxaphene	4
PAS 2	I, II, III, IV	Basic POPs in national POPs laboratory	aldrin, dieldrin, endrin, chlordane, DDT, alpha, beta, and gamma-HCHs, heptachlor, mirex, HCB, pentachlorobenzene, endosulfan, toxaphene	4
PAS 3	I, II, III, IV	Indicator PCB in expert back-up laboratory	6 indicator PCB	4
PAS 4	I, II, III, IV	Indicator PCB in national POPs laboratory	6 indicator PCB	4
PAS 5	I, II, III, IV	Dioxin-like POPs in expert back-up laboratory (combined into one extract as annual average)	17 PCDD/PCDF, 12 dl-PCB	1
PAS 6	I, II, III, IV	Dioxin-like POPs in national dioxin laboratory (combined into one extract as annual average)	17 PCDD/PCDF, 12 dl-PCB	1
PAS 7	I, II, III, IV	Dioxin-like POPs in expert back-up laboratory (each exposure to generate one seasonal data point; total of 4 per year and country)	17 PCDD/PCDF, 12 dl-PCB	4
PAS 8	I, II, III, IV	Dioxin-like POPs in national laboratory (each exposure to generate one seasonal data point; total of 4 per year and country)	17 PCDD/PCDF, 12 dl-PCB	4
PAS 9	I, II, III, IV	PBDE in expert laboratory	8 PBDE, HBCD, HBB	4
PAS 10	I, II, III, IV	PBDE in national laboratory	8 PBDE, HBCD, HBB	4
PAS 11	I, II, III, IV	PFOS in expert laboratory	3 PFAS	4
PAS 12	I, II, III, IV	For PFOS in national laboratory	3 PFAS	4

*Roman numbers (I, II, III, and IV) represent the sampling seasons

Note: Exposure periods are as follows

-Seasonal: 3 months with I=Jan-Mar, II=Apr-Jun, III=Jul-Sep, IV=Oct-Dec

-Annual: 4 PUFs from each 3-months exposure combined into one extract for analysis, maximum of 4 PUFs (with one PUF for each season).

All countries from the Pacific Islands project participated in the air monitoring with PAS/PUFs. The identification of the sampling sites is provided in Appendix in Table S 2, the geographic location indicated in Figure 1.

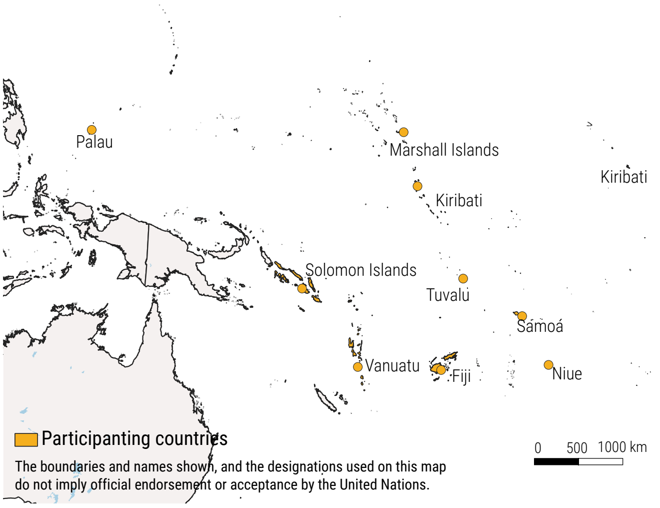


Figure 1: Geographical sketch of countries participating in the UNEP/GMP2 Pacific project (graphics, courtesy of Chemicals and Health Branch, Industry and Economy Division of UNEP)

Photographic impressions of the air sampling sites with the PAS exposed are shown below. The Marshall Islands, Niue, and Samoa did not provide photos.

Sampling site for air with PAS/PUF: Fiji, © The University of the South Pacific

Sampling site for air with PAS/PUF: Kiribati, © Ministry of Environment, Lands and Agriculture

Sampling site for air with PAS/PUF: Palau, © Palau Environmental Quality Protection Board

Sampling site for air with PAS/PUF: Solomon Islands, © Ministry of Environment, Climate Change, Disaster Management and Meteorology

Sampling site for air with PAS/PUF: Tuvalu, Metrological Service Area, © Tuvalu Department of Environment

Sampling site for air with PAS/PUF: Vanuatu, © Ministry of Climate Change Adaptation, Meteorology & Geo-Hazards

3.1.2. Core matrix water

PFAS were not among the initial twelve POPs at the onset of the Stockholm Convention in 2001 (entry into force in 2004) but were listed through the POPs review process. PFOS, its salts and perfluorooctanesulfonyl fluoride (PFOSF) have been listed into annex B in 2009 (Secretariat of the Stockholm Convention 2009) with an amendment in 2019 (Secretariat of the Stockholm Convention 2019b); PFOA, its salts and PFOA-related compounds have been listed in Annex A in 2019 (Secretariat of the Stockholm Convention 2019c). PFHxS is recommended for listing at the next meeting of the Conference of the Parties to the Stockholm Convention in 2021/2022 (Secretariat of the Stockholm Convention 2019a). With the listing of PFOS in 2009, water has been chosen as a core matrix (Weiss *et al.* 2015). So far, water is a core matrix in the GMP for the perfluorinated compounds only; not for any of the brominated or chlorinated POPs (UNEP 2021).

Surface water samples were collected by staff from local laboratories or institutions from developing countries participating in the water sampling activity of the UNEP/GMP2 projects. Across the projects, a total of 22 countries participated; of these all nine countries from the Pacific Islands region participated. The identification of the sampling sites is provided in Appendix in Table S3,

The graphical sketch of the water sampling sites is shown in Figure 2.

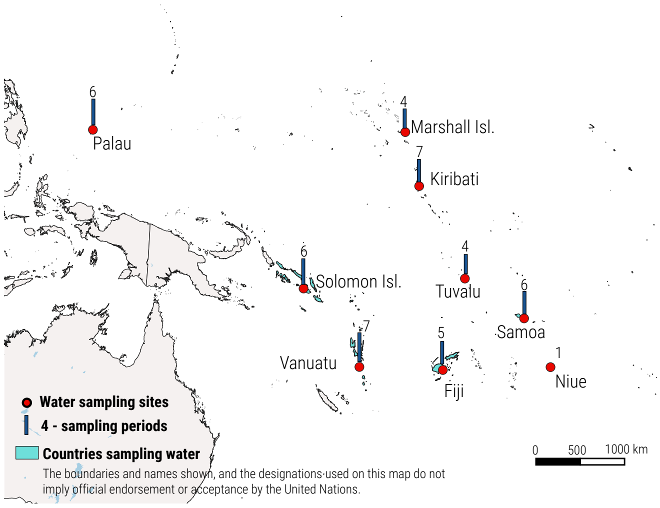


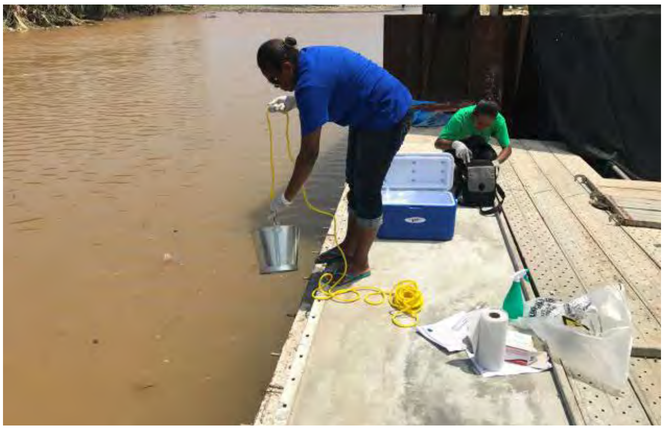
Figure 2: Geographical sketch of water sampling locations under UNEP/GMP2 Pacific Islands project

All water samples were collected according to the protocol for the sampling of water as a core matrix in the UNEP/GEF GMP2 projects (UNEP 2017c). To ensure integrity of the samples and to minimize contamination, each country had received nine 1-L high-density polyethylene (HDPE) bottles from Örebro University; it was attempted to have eight samples from each country plus one blank. The protocol prescribes to have an area- and time-integrative sampling location since sampling occurred only 4-times *per* year. Water samples were taken as surface water samples at a recommended depth of about 1 m from either the mouth of a large river, an estuary or bay in each country (for details of sampling locations, see Table S 3. One location for each country was chosen. Samples were taken at the end of each quarter of the year, classified into four intervals using the Roman numbers I, II, III, and IV, respectively. In total 144 water samples were analyzed globally; the Pacific Islands contributed with 46 samples, which corresponds to 64 % realization of the planned activities (9 countries with four samples per year during two years; thus, a total of eight samples per country). The water samples received by the expert laboratory are shown in Table 12.

Photographic impressions of the water sampling sites are shown Photographic impressions of the water sampling sites are shown below. Fiji, Kiribati, Marshall Islands, Niue did not provide photos.

Sampling site for water: Palau, © Palau Environmental Quality Protection Board

Sampling site for water: Samoa, © Ministry of Natural Resources and Environment



Sampling site for water: Solomon Islands, © Ministry of Environment, Climate Change, Disaster Management and Meteorology

Sampling site for water: Tuvalu, southern end of Fongafale Island (Funafuti), © Tuvalu Department of Environment

Sampling site for water: Vanuatu, © Ministry of Climate Change Adaptation, Meteorology & Geo-Hazards

3.1.3. Core matrix human milk

Human milk samples have been collected as national pools and sent for analysis. Sample collection, preparation of the pools and handling are described in the protocol developed by UNEP for the human milk studies (UNEP 2017a) and the GMP guidance document (UNEP 2021). Most important, donor mothers should be primipara and collected between three and twelve weeks after delivery.

Below are 3 briefs accounts of the human milk sampling procedures followed by Palau, Tuvalu and the Solomon Islands.

Palau

The human milk survey was conducted by the Ministry of Health with contractors, The Environment Inc. (TEI) and the Pacific Academic Institute for Research (PAIR). In brief, nursing staff trained under the previous GMP project were used again to help extract milk from participating mothers. Nurses of the Belau National Hospital collected 32 samples from first time mothers following breastmilk sampling guidelines (UNEP 2017a).

All samples were sent to CVUA, Fribourg and subsequently one aliquot to Örebro University, School of Science and Technology, MTM Research Center, Sweden.

Tuvalu

In March 2018, a formal letter was submitted by the former Ozone Depleting Substance (ODS) Project Coordinator, Mrs. Setapu Resture, Department of Environment to the Ministry of Health asking for proper permission with regards to activities under the GMP 2 for human milk sampling. The letter of request was approved on 28 March 2018. The national activities included the following:

- Questionnaires for mothers were formulated and translated in Tuvaluan for a better understanding of mothers.
- The Tuvalu Post & Antenatal Clinic provided a list of 28 mothers (primigravida) for the said activity.
- With regards to the list provided, interviews were conducted on 23 April 2018 between mothers and the survey team.
- Equipment for sampling activities were provided by the project and consisted of 100 mL glass bottles for individual samples and one 2 L glass bottle for the national pool. The mothers who supplied milk samples for the project were given a resource fee of $50.
- Milk samples were collected by the ODS Project Coordinator at the Post & Antenatal Clinic where mothers submitted their milk samples.
- By June 2019, 15 mothers had provided their samples (*i.e.*, 15 mothers = 125 mL); they were stored in the project's refrigerator. Potassium dichromate was added into samples.
- These samples could not be sent to designated laboratories merely because one of the officers in the department was unaware of the samples in the refrigerator and accidentally turned off the main switch, and as a result, samples got contaminated.

Solomon Islands

The sampling was conducted at the National Referral Hospital in Honiara. The survey participants reside all over the Honiara City. No samples from the other provinces were collected.

The WHO guidelines recommend that a country should have a minimum of 50 individual samples per country to get a statistically reliable data. For Round 6 (2019) of the human milk sampling, 50 individual samples were collected.

In order to conduct research within the National Referral Hospital (NRH), which is governed by the Ministry of Health and Medical Services (MHMS), the project has to seek approval from the Solomon Islands Health Research and Ethics Review Board (SIHRERB). This process alone took almost 2 years before the board granted approval.

When trying to assess overall human exposure to POPs, human milk sampling is preferable because it is a non-invasive sampling method, which has advantages over collection of other biological samples such as blood and tissue.

A summary of the methodology conducted to collect the samples is outline below.

1. Donors are identified. Donors should meet the following criteria:
    - Mother should be primiparae (first-time mothers).
    - Mother should be under 30 years of age.
    - Both mother and child should be apparently healthy, including normal pregnancy.

- Mother should be breastfeeding one child only (*i.e.*, no twins).
- Mother should have resided in the represented area (country) for at least the previous ten years.
- Mother should not reside in local areas where emissions of POPs are known or suspected to result in elevated concentrations of POPs in the local population.
- Mothers should be available for sample collection within 3 to 8 weeks of delivery

2. Donors must fill in a questionnaire and if assistance is needed, the nurse in charge can assist. Donors were required to sign a consent form
3. Donors are given a 100 ml bottle and each mother is required to collect 50ml of human milk.
4. Once the samples are collected, they are stored in a freezer.
5. Before shipment, the samples are then pooled into a 2000 ml bottle by qualified personnel and in the case of Solomon Islands a Lab Technician of the National Referral Hospital. This is to ensure the integrity of the sample. The samples are split into 2 portions of 25ml each. 25ml is pooled and for analysis at the lab specified by UNEP and 25ml is kept as an individual sample in country.

3.2. Results generated by national laboratories

During the project implementation period, there was no operational POPs laboratory in the Pacific Islands regions. Subsequently, no nationally generated results could be delivered.

Collaboration with the University of Queensland, Australia was established. The joint activities did not follow the recommended analytical approach, rather used passive water samplers for PFAS. The air sampling could not be realized. For further information, see section 6.1 and the national report by Fiji.

Photo: ©Pexels / Polina Tankilevitch

SECTION 4

Results from expert laboratories

Photo: ©Pexels / Gustavo Fring

4. RESULTS FROM EXPERT LABORATORIES

Chemical analysis of all samples collected in the Pacific Islands region were analyzed by so-called 'expert laboratories' with the following assignments according to POPs group and matrix:

- E&H VU Vrije Universiteit in Amsterdam, the Netherlands (formerly IVM): Air and national samples: Organochlorine pesticides (OCP), indicator PCB (PCB_6), PBDE, [HBB, HBCD]
- MTM Research Centre, Örebro University in Örebro, Sweden: Air, water, human milk [PFOS, PFOA, PFHxS]
- CVUA Freiburg, Germany: Human milk: OCP, PCB_6, toxaphene, [PBDE, HBCD, HBB, PCN and SCCP]

Groups of POPs printed in [square brackets] were not analyzed in the GMP1 projects. Note: the group of the OCP contains some pesticides that were listed as 'new' POPs such as endosulfan, HCH isomers (although voluntarily already included in the GMP1, chlordecone, pentachlorobenzene, HCBD. For these, no comparative data were available when examining the results of the GMP2 projects across all projects.

The list of POPs above includes more POPs than those included in the approved project document (UNEP 2015c).

4.1. Chemical analysis and reporting of results

Generic protocols for the analysis of POPs had been developed in a previous GEF project for OCPs and indicator PCB (PCB_6) (UNEP 2014a), PBDE (UNEP 2014b), and PFAS (UNEP 2015d). They were used in this GMP2 project. In brief, brominated and chlorinated POPs were analyzed using GC/MS instrumentation whereby dl-POPs were detected with HRMS as sector-field instruments. PFAS were analyzed using LC/MSMS.

POPs were determined as the mass concentration (ng or pg) extracted from the PUFs. For certain groups of POPs, such as dl-POPs or toxaphene, it was recommended to combine four PUFs to an annual sample. For comparison of results, all data were normalized to one PUF and a 3-month exposure time.

For the sums of OCPs, the mass concentrations were added and no 'equivalents' used. Concentrations for OCPs, PCB_6, and brominated flame retardants (BFRs) in air were reported in ng/PUF and in nanogram per gram lipid (ng/g lipid) for human milk.

For dl-POPs, all values of the 29 compounds were calculated as toxic equivalents (TEQ) using the 2005 WHO TEF scheme (van den Berg *et al*. 2006).

The TEQs are reported for the combined PCDD/PCDF, namely for seven 2,3,7,8-substituted PCDD and ten 2,3,7,8-substituted PCDF (expressed as TEQ_DF) and TEQ for 12 non-ortho and mono-ortho PCB (expressed as TEQ_PCB). Concentrations for dl-POPs were reported in picogram per PUF (pg TEQ/PUF) for PAS/PUF air samples, and picogram *per* gram lipid (pg/g lipid) for human milk.

In order to compare, results should be reported according to number of PUFs (and exposed); thus, when four PUFs were combined, the amount should be divided by a factor of 4 to receive the amount *per* PUF. For HBCD, first a screening using GC/MS should be performed and only samples, where HBCD was quantifiable in the GC/MS screening will undergo isomer-specific analysis using LC/MS.

Concentrations for PFAS were reported in picogram per PUF (pg/PUF) in air, pg/g fresh weight (f.w.) in human milk, and nanogram per liter (ng/L) for water.

Since no conversion to volume was made, temperature, windspeed, precipitation or characteristics of the PUFs (density) were not considered.

4.2. Ambient air

4.2.1. Chlorinated POPs

Data are available from 49 datasets as shown in Table 4; the summary of results per group of chlorinated POPs (Cl-POPs, as sums of isomers or congeners) are shown in Table 5. Graphical sketches provide the summary and comparison of results of chemical analyses for Cl-POPs as Figure 3. All data refer to 1 PUF and approximately 3 months of exposure time and are given in ng/PUF.

Table 4: Number of PUFs per country and year, analyzed for Cl-POPs

	Y2017 (N=11)	Y2018 (N=28)	Y2019 (N=10)	Overall (N=49)
FJI	1	3	3	7
KIR	2	4	1	7
MHL	1		1	2
NIU	2	4	2	8
PLW	3	3		6
WSM		2		2
SLB	2	4	1	7
TUV		4		4
VUT		4	2	6

The highest mean and median values were found for DDT with a large difference between the mean (55.4 ng/PUF) value and the median value (1.43 ng/PUF). The values peaked in the Solomon Islands, SLB, with little variation between measurements; followed by TUV and FJI. The median values for PCB_6 (2.46 ng/PUF), HCBD (2.20 ng/PUF), and HCB (2.00 ng/PUF) were higher than for DDT. PCB_6 peaked in WSM, HCB was almost equally present in most countries the maximum was found in PLW. HCBD was present at similar concentrations in all countries, except Fiji, where lower values were found. For chlordane and drins, mean and median values were similar. From Table 5 it can be seen that for α-endosulfan and toxaphene, the median values were zero. α-Endosulfan was quantified only in SLB.

The concentrations of chlorinated POPs in each sample per country are shown in Figure 8. It shall be noted that in some figures the extreme values for DDT in SLB or PCB_6 in WSM can be out of scale and not fully shown.

A statistical assessment showed that the concentrations of the Cl-POPs were significantly different between the countries: the Kruskal Wallis ranking test had a p-value of 2.8×10^{-9}. Pairwise comparison between two countries gave p-values <0.5 for FJI with KIR, NIU, VUT; KIR with PLW, SLB, TUV; MHL with PLW, TUV; WSM with SLB, SLB with VUT, and TUV with VUT.

Agricultural rice field near coconut palm tree on farmland

Table 5: Chlorinated POPs in PAS/PUF: Mean (with standard deviation, SD), median, minimum and maximum values (ng/PUF)

POPs	Central tendencies	FJI (N=7)	KIR (N=7)	MHL (N=2)	NIU (N=8)	PLW (N=6)	WSM (N=2)	SLB (N=7)	TUV (N=4)	VUT (N=6)
chlordane	Mean (SD)	1.33 (0.485)	0.360 (0.279)	0.430 (0.028)	1.79 (0.491)	6.71 (2.01)	0.475 (0.021)	6.76 (4.51)	0.583 (0.068)	0.277 (0.228)
	Median [Min, Max]	1.19 [0.890, 2.35]	0.400 [0, 0.710]	0.430 [0.410, 0.450]	1.97 [0.590, 2.06]	6.80 [3.56, 9.60]	0.475 [0.460, 0.490]	4.41 [2.70, 14.2]	0.565 [0.520, 0.680]	0.350 [0, 0.480]
drins	Mean (SD)	2.39 (0.797)	0.521 (0.743)	0 (0)	0 (0)	3.07 (2.24)	0 (0)	8.66 (2.88)	1.98 (0.907)	0.378 (0.481)
	Median [Min, Max]	2.40 [1.50, 3.50]	0.480 [0, 2.10]	0 [0, 0]	0 [0, 0]	2.25 [1.70, 7.60]	0 [0, 0]	8.25 [5.51, 14.2]	1.65 [1.30, 3.30]	0.245 [0, 1.20]
DDT	Mean (SD)	6.32 (2.36)	0.897 (0.354)	0 (0)	1.38 (0.286)	1.41 (0.598)	1.38 (0.495)	370 (159)	12.6 (6.26)	0.470 (0.143)
	Median [Min, Max]	6.61 [3.81, 10.1]	0.880 [0.320, 1.43]	0 [0, 0]	1.34 [0.950, 1.99]	1.56 [0.440, 1.93]	1.38 [1.03, 1.73]	325 [228, 667]	12.4 [5.82, 19.9]	0.425 [0.350, 0.720]
heptachlor	Mean (SD)	0.661 (0.788)	0.373 (0.320)	0 (0)	1.09 (0.494)	0.987 (0.348)	0.265 (0.375)	0.746 (0.371)	0.200 (0.265)	0.033 (0.052)
	Median [Min, Max]	0.630 [0, 2.17]	0.600 [0, 0.660]	0 [0, 0]	1.00 [0.430, 2.20]	1.05 [0.440, 1.42]	0.265 [0, 0.530]	0.630 [0.280, 1.32]	0.105 [0, 0.590]	0 [0, 0.100]
mirex	Mean (SD)	0.116 (0.054)	0.120 (0.055)	0 (0)	0 (0)	0.185 (0.109)	0.125 (0.007)	0.466 (0.635)	0.075 (0.088)	0.035 (0.055)
	Median [Min, Max]	0.130 [0, 0.160]	0.140 [0, 0.160]	0 [0, 0]	0 [0, 0]	0.210 [0, 0.320]	0.125 [0.120, 0.130]	0.230 [0.160, 1.90]	0.065 [0, 0.170]	0 [0, 0.120]
toxaphene	Mean (SD)	0.024 (0.064)	0.100 (0.182)	0.780 (0.509)	0.021 (0.060)	0.123 (0.096)	0 (0)	0 (0)	0.055 (0.110)	0.057 (0.088)
	Median [Min, Max]	0 [0, 0.170]	0 [0, 0.460]	0.780 [0.420, 1.14]	0 [0, 0.170]	0.175 [0, 0.200]	0 [0, 0]	0 [0, 0]	0 [0, 0.220]	0 [0, 0.170]
endosulfan	Mean (SD)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.771 (1.12)	0 (0)	0 (0)
	Median [Min, Max]	0 [0, 0]	0 [0, 0]	0 [0, 0]	0 [0, 0]	0 [0, 0]	0 [0, 0]	0 [0, 2.90]	0 [0, 0]	0 [0, 0]
HCHs	Mean (SD)	4.09 (1.27)	0.267 (0.435)	0 (0)	0.510 (0.224)	0.340 (0.364)	0 (0)	0.706 (0.229)	2.38 (1.71)	0.542 (0.594)
	Median [Min, Max]	3.85 [2.64, 6.66]	0.170 [0, 1.22]	0 [0, 0]	0.450 [0.310, 1.05]	0.265 [0, 0.950]	0 [0, 0]	0.710 [0.460, 1.14]	1.70 [1.20, 4.90]	0.395 [0, 1.67]
PCB6	Mean (SD)	3.23 (1.65)	0.949 (0.333)	1.45 (0.375)	1.54 (0.169)	3.86 (1.94)	36.7 (33.8)	2.93 (0.198)	3.39 (0.591)	3.23 (2.92)
	Median [Min, Max]	3.03 [1.74, 6.62]	0.780 [0.680, 1.52]	1.45 [1.18, 1.71]	1.59 [1.20, 1.71]	3.67 [1.39, 5.99]	36.7 [12.8, 60.6]	2.86 [2.73, 3.25]	3.49 [2.58, 4.00]	1.81 [0.990, 8.13]
HCB	Mean (SD)	2.67 (0.298)	2.13 (0.550)	1.65 (0.0707)	1.00 (0.351)	4.40 (1.70)	2.25 (0.354)	1.86 (0.299)	2.85 (1.02)	1.62 (0.468)
	Median [Min, Max]	2.70 [2.20, 3.10]	2.30 [1.20, 2.70]	1.65 [1.60, 1.70]	0.940 [0.640, 1.80]	3.75 [3.10, 7.70]	2.25 [2.00, 2.50]	1.90 [1.40, 2.30]	2.70 [1.80, 4.20]	1.70 [0.820, 2.10]
PeCBz	Mean (SD)	0.970 (0.426)	0.660 (0.312)	0.685 (0.318)	0.418 (0.172)	1.46 (0.635)	0.580 (0.014)	0.470 (0.282)	0.755 (0.051)	0.285 (0.146)
	Median [Min, Max]	0.840 [0.520, 1.60]	0.470 [0.380, 1.20]	0.685 [0.460, 0.910]	0.475 [0, 0.520]	1.30 [0.890, 2.60]	0.580 [0.570, 0.590]	0.370 [0.300, 1.10]	0.745 [0.710, 0.820]	0.345 [0, 0.380]
HCBD	Mean (SD)	0.767 (0.156)	3.87 (1.54)	2.65 (0.636)	2.51 (1.62)	1.12 (0.726)	3.95 (0.636)	2.76 (2.38)	3.35 (0.759)	2.18 (0.999)
	Median [Min, Max]	0.700 [0.580, 1.00]	3.60 [2.00, 6.80]	2.65 [2.20, 3.10]	2.70 [0, 4.80]	1.04 [0, 2.10]	3.95 [3.50, 4.40]	1.70 [0.540, 6.30]	3.45 [2.40, 4.10]	2.05 [1.10, 3.50]

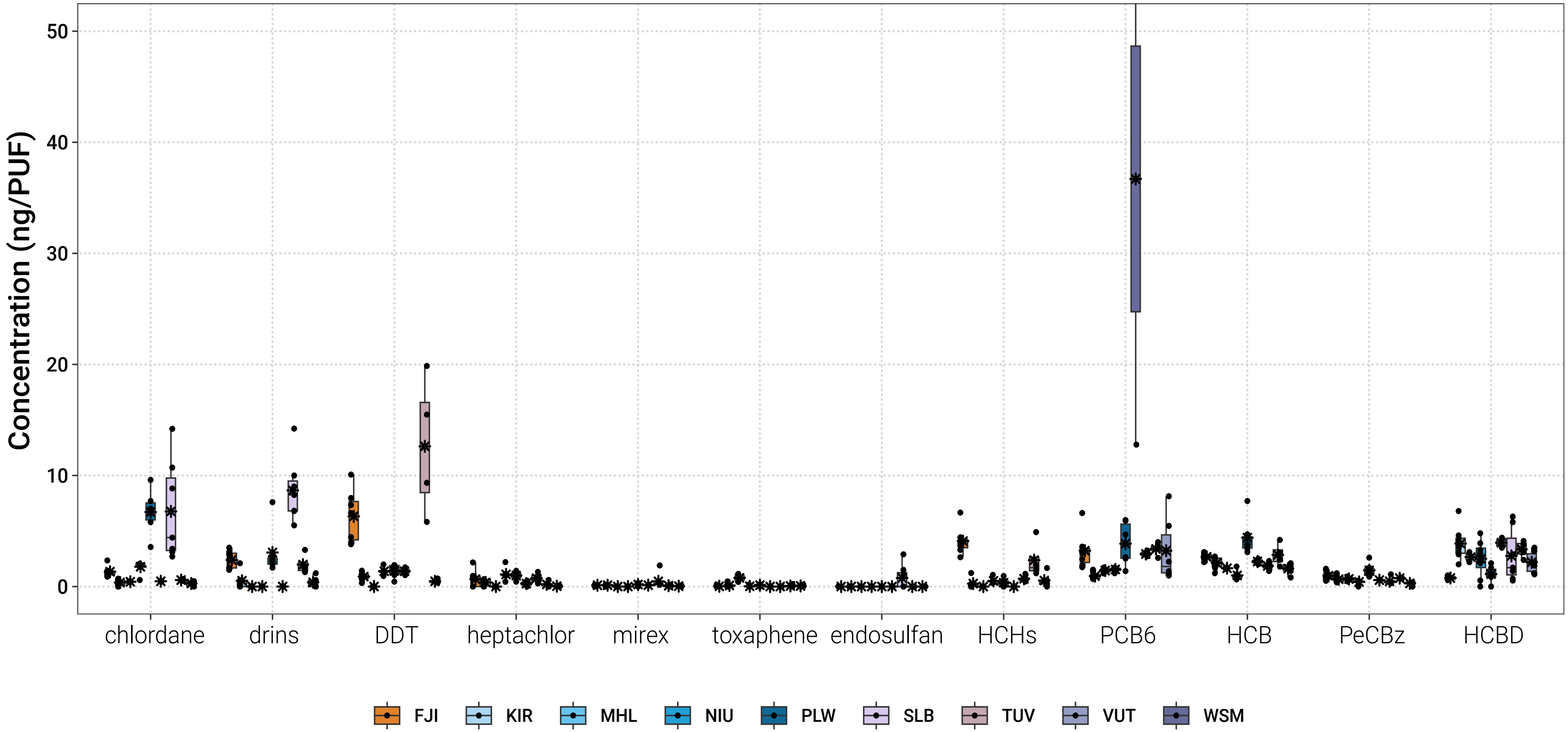


Figure 3: PAS/PUF: Box plots for chlorinated POPs in PAS/PUFs: summary across all samples (n=49); y-axis zoomed to 50 ng/PUF. Note: the box plot for the high concentrations of DDT in SLB is located outside of the scale

Box 1 for all the box and whiskers plots in this report:

The whiskers represent the minimum and maximum values without the outliers. The lower border of the box represents the first quartile (25%), the line inside the box the median and the upper border is the third quartile (75%). The asterisk represents the mean value. The dots outside the whiskers are outliers, which were defined as all values greater or smaller the interquartile range multiplied by 1.5

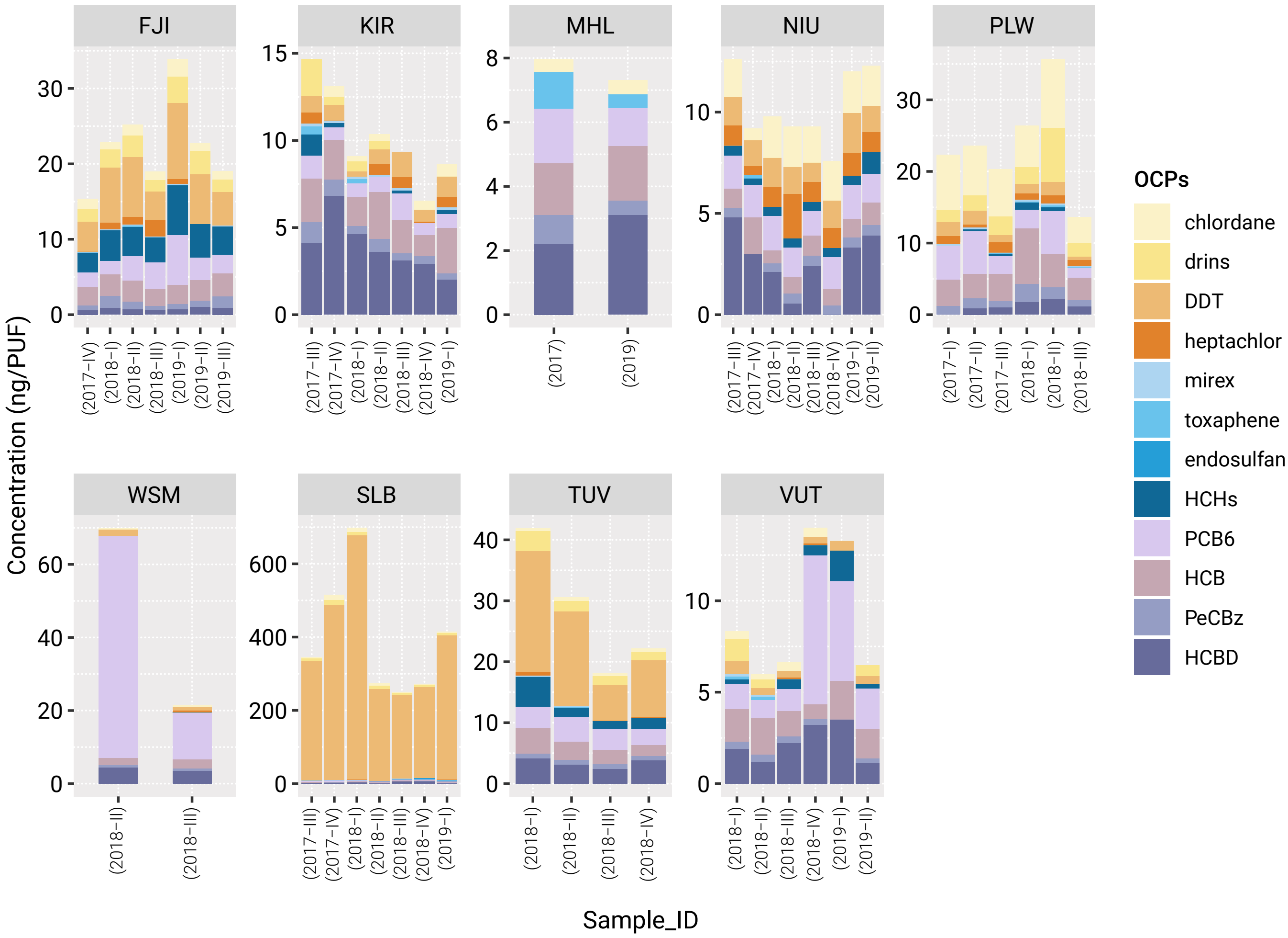


Figure 4: PAS/PUF: Stacked bar graphs for chlorinated POPs by country and sample (n=49)

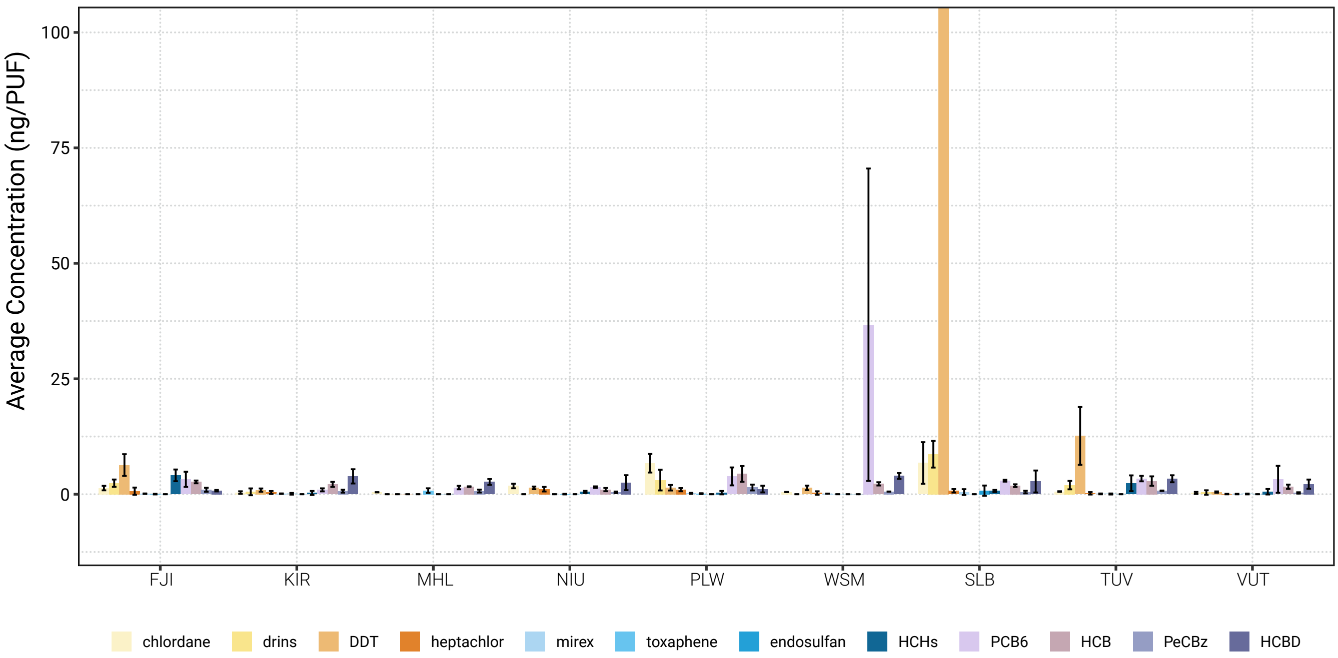


Figure 5: PAS/PUF: Mean values and SD for chlorinated POPs in PAS/PUF (n=49)

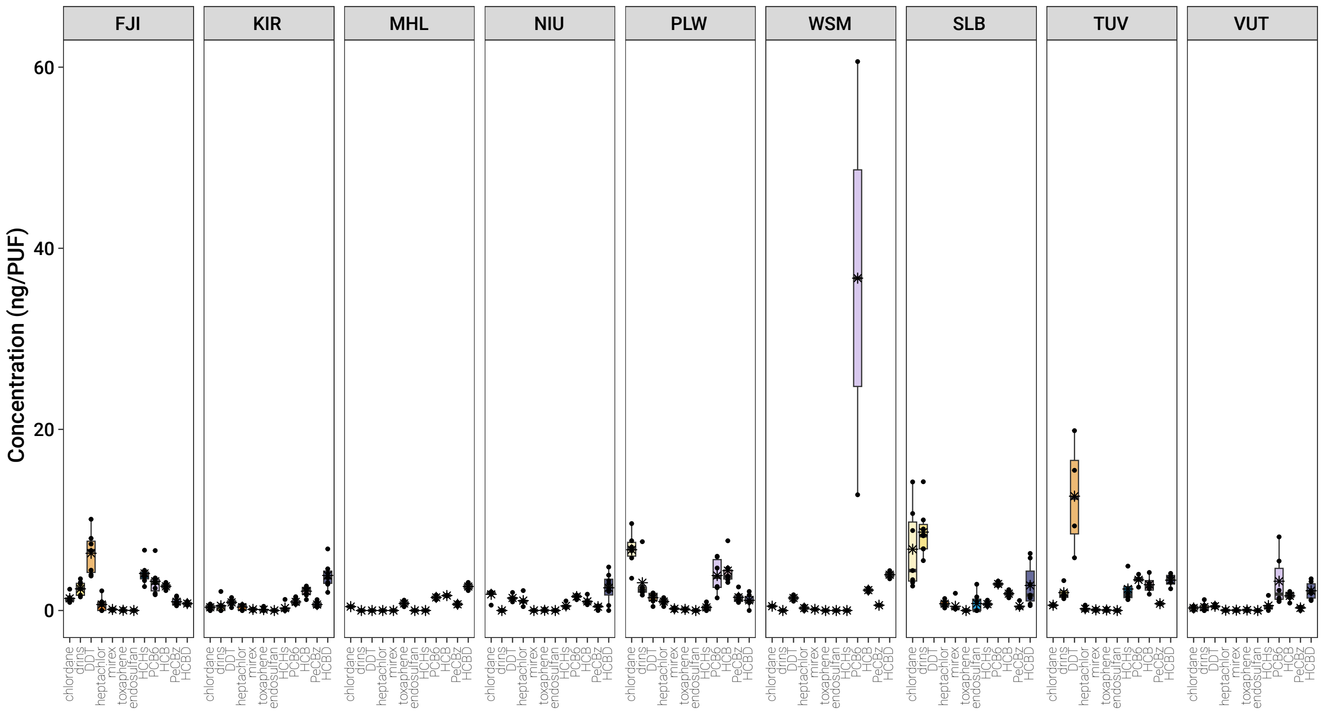


Figure 6: PAS/PUF: Unscaled boxplots for chlorinated POPs in air per country (n=49). Concentrations in ng/PUF. Note: y-axis zoomed to 75 ng/PUF; DDT value from SLB is out of the graphic.

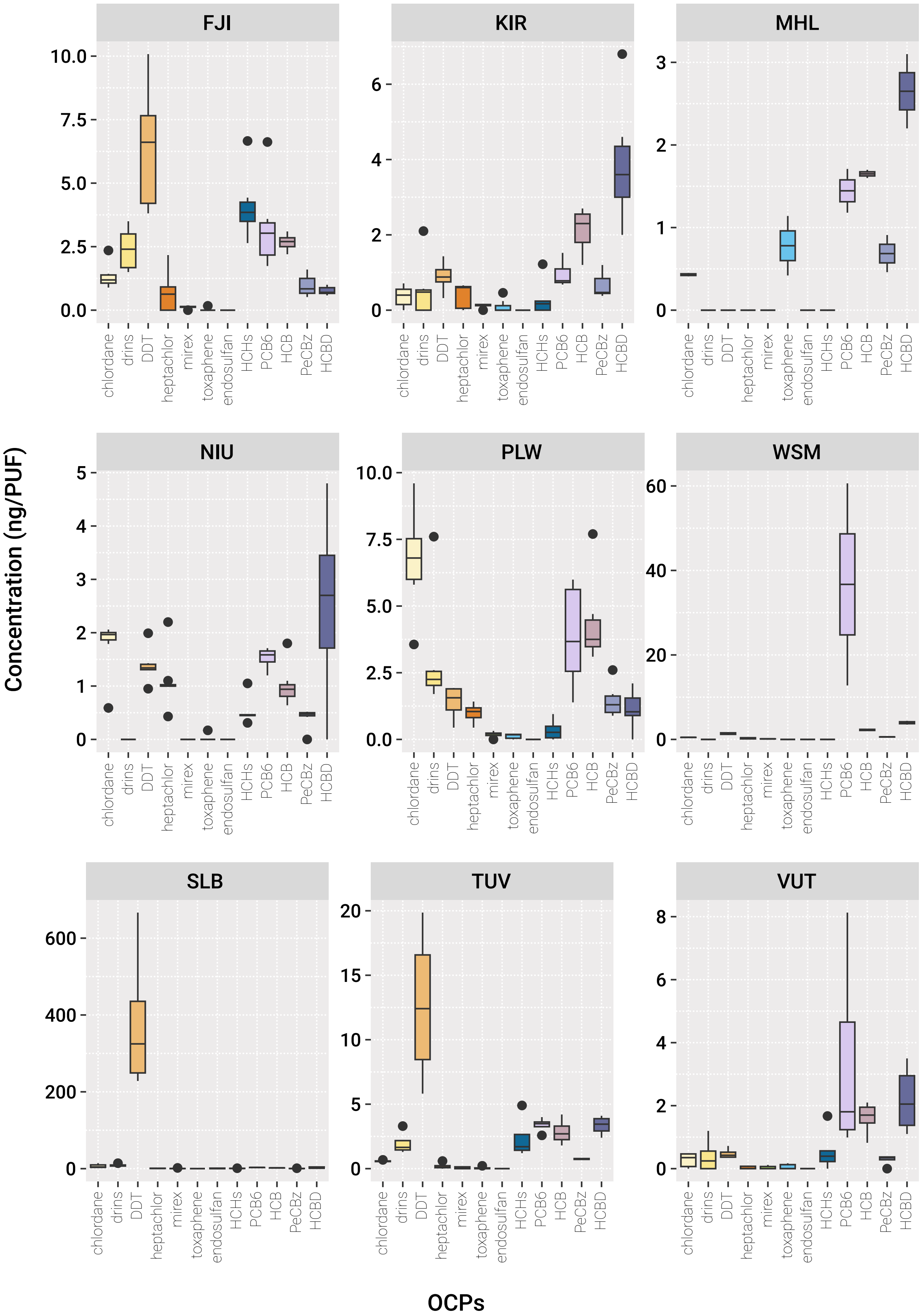


Figure 7: PAS/PUF: Scaled boxplots for sums of chlorinated POPs by country(n=49)

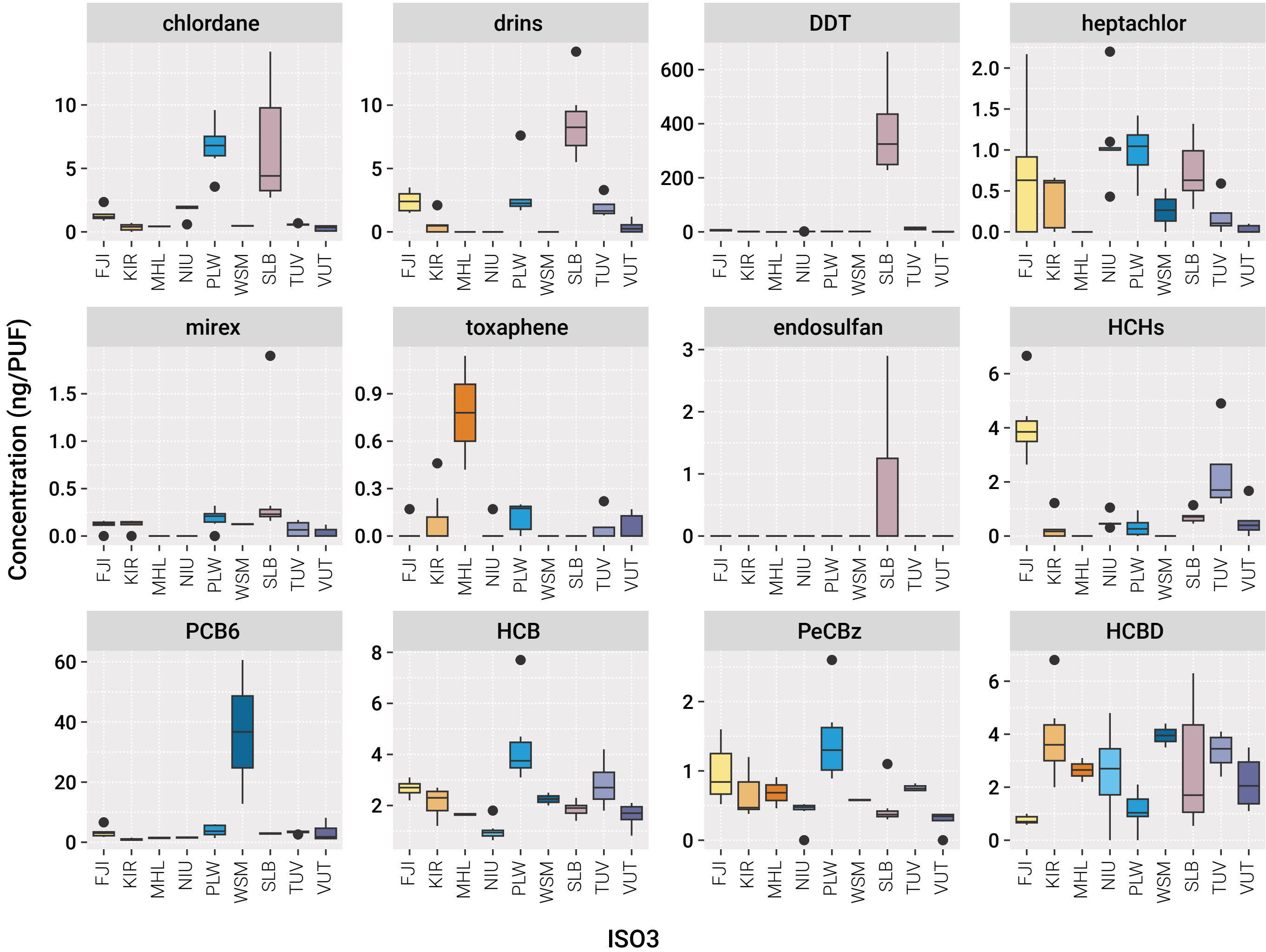


Figure 8: PAS/PUF: Scaled boxplots for country by chlorinated POP (n=49)

4.2.2. Dioxin-like POPs

In total, 23 samples have been analyzed for dl-POPs (Table 6). Of these, 7 samples were quarterly, *i.e.,* one PUF exposed for 3 months. Since concentrations were often very low, they were combined into an annual sample as was planned. The number and origin of the samples are shown in Table 6.

The results of the PUF extracts are detailed in Table S 5.

Table 6: Number of PUFs per country and year, analyzed for dl-POPs

	Y2017 (N=11)	Y2018 (N=10)	Y2019 (N=2)	Overall (N=23)
ISO3				
FJI	1	1	1	3
KIR	1	1		2
MHL		1		1
NIU	1	1	1	3
PLW	4	1		5
WSM		2		2
SLB	3	1		4
TUV	1	1		2
VUT		1		1
Sample type				
Annual	2	7		9
Consecutive	3	2	2	7
quarterly	6	1		7

Table 7 provides the mean, median, minimum and maximum values for each country. The values refer to pg TEQ per number of PUFs that had been extracted together. For some countries, *i.e.,* those that indicated to have national dioxin analytical capacities, single individual PUFs were analyzed by the expert laboratory. Other countries, with no dioxin analytical capacity, the seasonal PUFs were combined to an annual sample. For assessment and to compare the results, all samples were normalized to 1 PUF and 1 quarter of year, *i.e.,* 3-month exposure time. Graphical sketches provide the summary and comparison of results of chemical analyses for dl-POPs, shown as partial TEQs for PCDD/PCDF (defined as TEQ_DF) and dl-PCB (defined as TEQ_PCB). Results are from quarterly or annual samples (combinations of more than 1 PUF) as shown in Table 7. The Sample_ID identifies quarterly samples by the Roman number for the quarter; annual samples are designated by the letter "A". All data refer to 1 PUF and 3 month of exposure time and are given in pg TEQ/PUF.

Graphical sketches provide the summary and comparison of results as TEQ. The stacked bars showed that the highest TEQ values were found in the SLB and FJI, whereby the highest single value and the highest median value for TEQ_DF was in SLB and the highest single and median values for TEQ_PCB in FJI (Figure 9 and Table 7). Figure 10 shows an overview of the results by country and TEQ as box whisker plots. The mean values with standard deviations are shown in Figure 11. For each country, the results are displayed in Figure 12, Figure 13, and Figure 14.

The Kruskal Wallis test for two TEQs gave significant differences between countries ($p=6.88 \times 10^{-5}$). Pairwise assessment shows that most significant differences for FJI with KIR (p=0.038), NIU (p=0.024), TUV (p=0.038), NIU with PLW (p=0.018), SLB (p=0.018), and TUV (p=0.038), KIR with SLB (p=0.024), SLB with PLW (p=0.024), SLB with TUV (p=0.024).

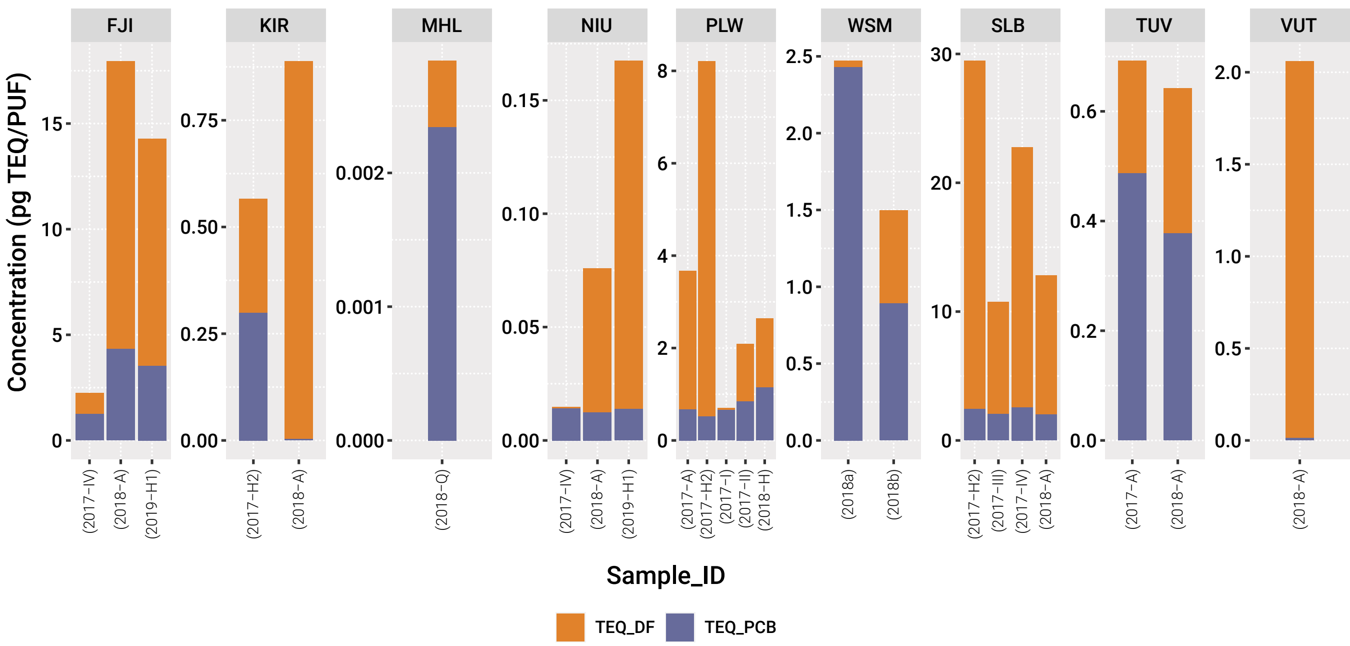


Figure 9: PAS/PUF: Stacked bar graphs for dl-POPs as two TEQs by country and sample (n=23)

Table 7: Partial TEQs in PAS/PUF: Mean (with standard deviation, SD), median, minimum and maximum values (pg TEQ/PUF and 3 month)

POPs	Central tendencies	FJI (N=3)	KIR (N=2)	MHL (N=1)	NIU (N=3)	PLW (N=5)	WSM (N=2)	SLB (N=4)	TUV (N=2)	VUT (N=1)	Overall (N=23)
TEQ_DF	Mean (SD)	8.46 (6.62)	0.576 (0.438)	0.000495	0.073 (0.077)	2.69 (2.99)	0.323 (0.400)	16.7 (8.51)	0.235 (0.042)	2.05	4.79 (7.34)
	Median [Min, Max]	10.7 [1.01, 13.6]	0.576 [0.267, 0.886]	0.0005	0.0634 [0.001, 0.154]	1.49 [0.0433, 7.70]	0.323 [0.040, 0.606]	15.5 [8.72, 27.0]	0.235 [0.205, 0.265]	2.05	1.01 [0.0005, 27.0]
TEQ_PCB	Mean (SD)	3.04 (1.60)	0.151 (0.209)	0.00234	0.013 (0.001)	0.768 (0.239)	1.66 (1.09)	2.26 (0.277)	0.432 (0.077)	0.0125	1.15 (1.23)
	Median [Min, Max]	3.54 [1.25, 4.32]	0.151 [0.003, 0.299]	0.00234	0.0138 [0.012, 0.014]	0.675 [0.517, 1.14]	1.66 [0.892, 2.43]	2.23 [2.01, 2.56]	0.432 [0.378, 0.487]	0.0125	0.675 [0.002, 4.32]

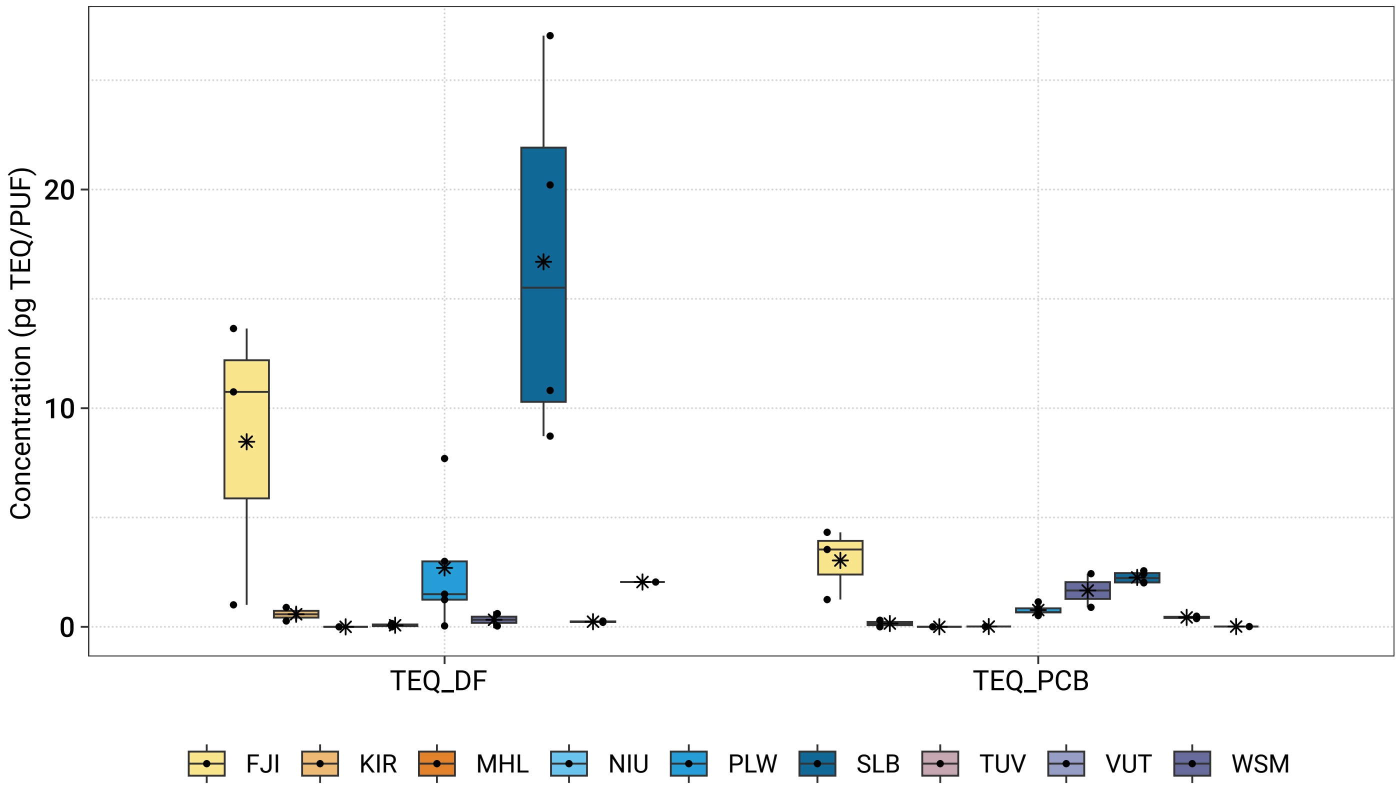


Figure 10: PAS/PUF: Unscaled box whisker plots for dl-POPs by (N=23)

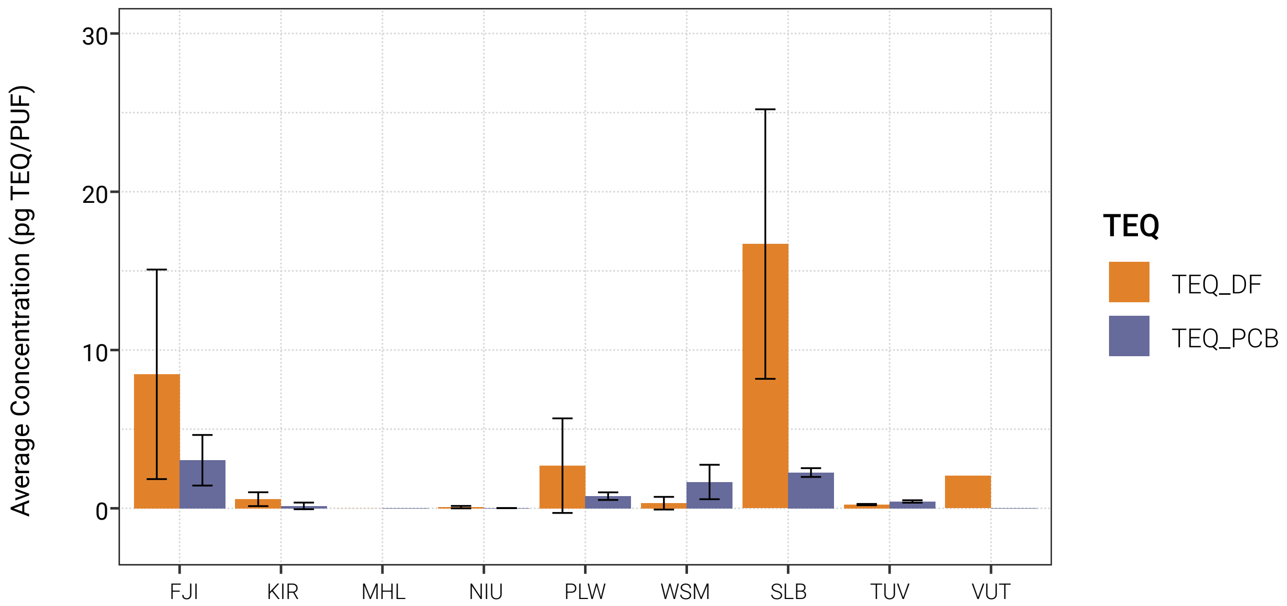


Figure 11: PAS/PUF: Mean values and SD for dl-POPs for countries (n=23)

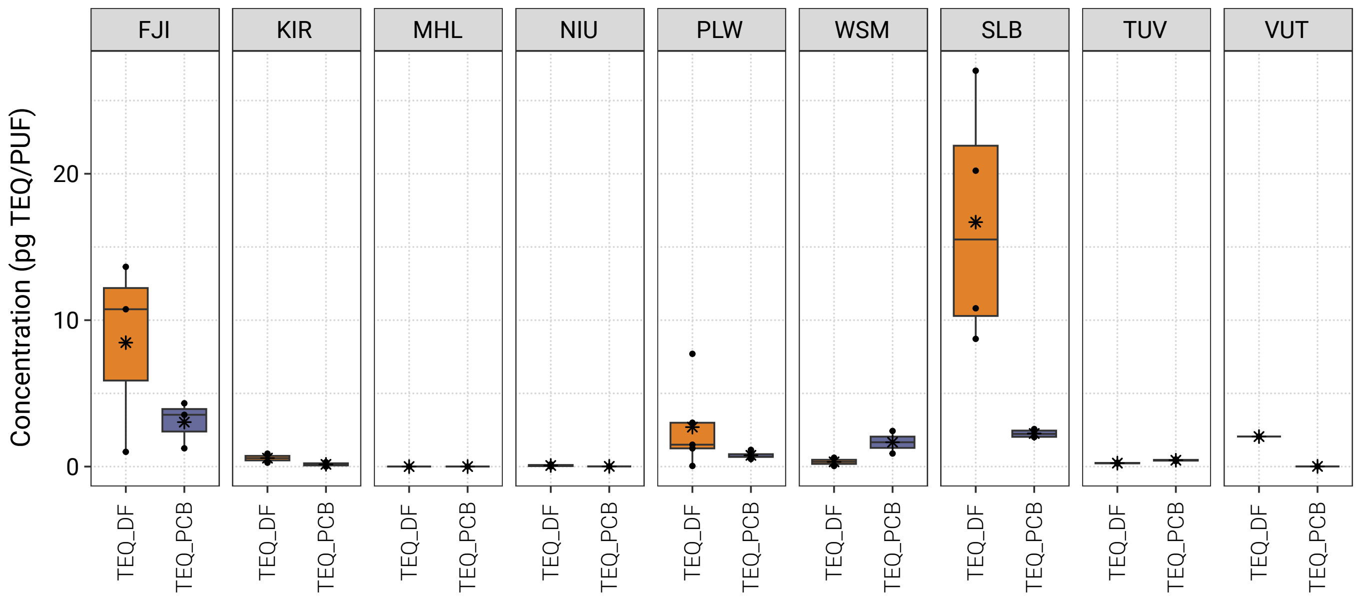


Figure 12: PAS/PUF: Box whisker plots unscaled for dl-POPs (for 2 TEQ) per country (n=23)

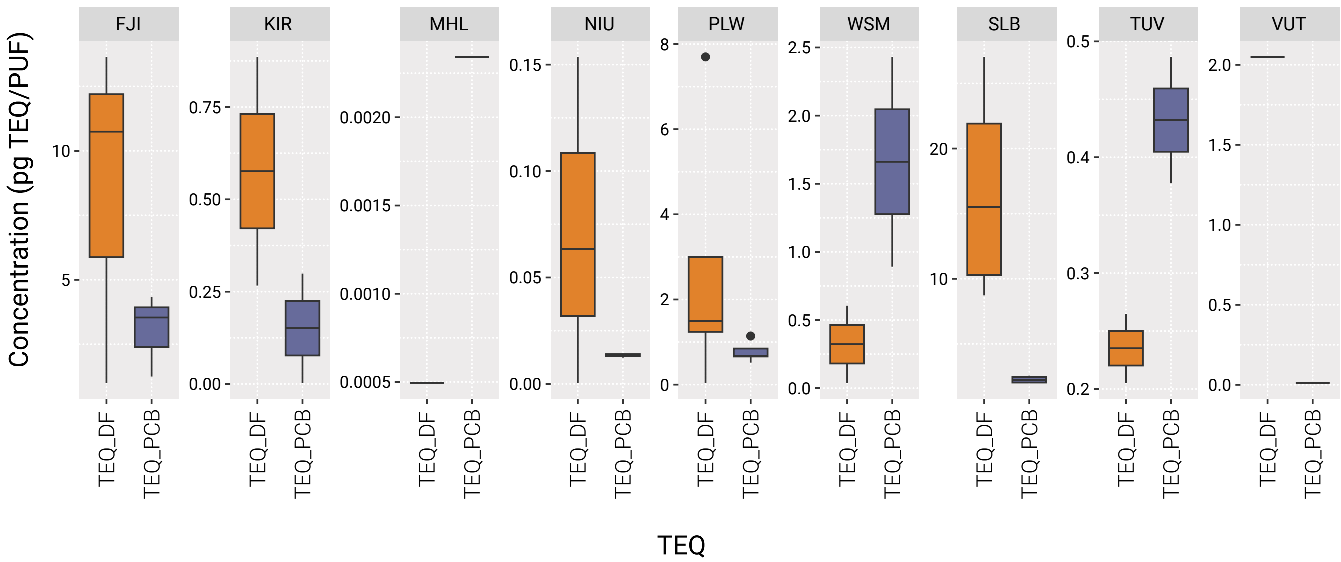


Figure 13: PAS/PUF: Scaled boxplots for concentrations of two TEQs by country (n=23)

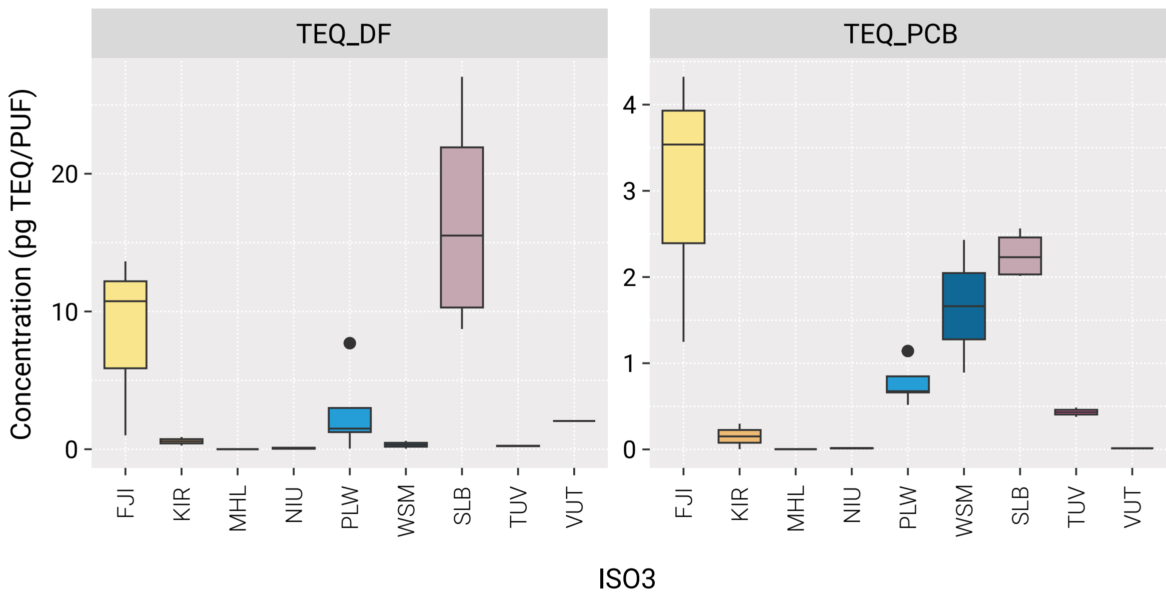


Figure 14: PAS/PUF: Scaled boxplots for concentrations by 2 TEQs for country (N=23)

4.2.3. Brominated POPs

Brominated POPs (Br-POPs) included PBDE (eight substances) and in addition PBDE 209, which was listed in 2017 (Secretariat of the Stockholm Convention 2017), PBB153 and three stereoisomers of HBCD (Table 1).

49 samples were analyzed for Br-POPs; the contributing countries are shown in Table 8. It can be seen that NIU provided eight samples whereas MHL and WSM sent only two samples for analysis.

The summary, descriptive statistics is shown in Table 9. The values of the four BFRs are shown as stacked bars for each sample in Figure 15. Overall, $PBDE_8$ had higher mean and median values than HBCD. The highest $PBDE_8$ was found in FJI (14.9 ng/PUF) followed by MHL. HBCD was elevated in VUT (mean value = 9.6 ng (PUF) up to a maximum of 48.8 ng/PUF (Figure 18 and Figure 20). PBDE 209 was quantified in some but not all countries. The highest value was found in PLW (12.0 ng/PUF) (Figure 20). Also, PBB 153 was quantified only in very few samples at very low concentrations; the highest amount was 0.23 ng/PUF in the sample from Vanuatu.

There were significant differences between countries; p=0.0016 but only two pairwise significances could be determined. Significant differences were found for PLW with NIU (p=0.007) and with SLB (p=0.039).

Table 8: Number of PUFs per country and year, analyzed for Br-POPs

	Y2017 (N=11)	Y2018 (N=28)	Y2019 (N=10)	Overall (N=49)
FJI	1	3	3	7
KIR	2	4	1	7
MHL	1		1	2
NIU	2	4	2	8
PLW	3	3		6
WSM		2		2
SLB	2	4	1	7
TUV		4		4
VUT		4	2	6

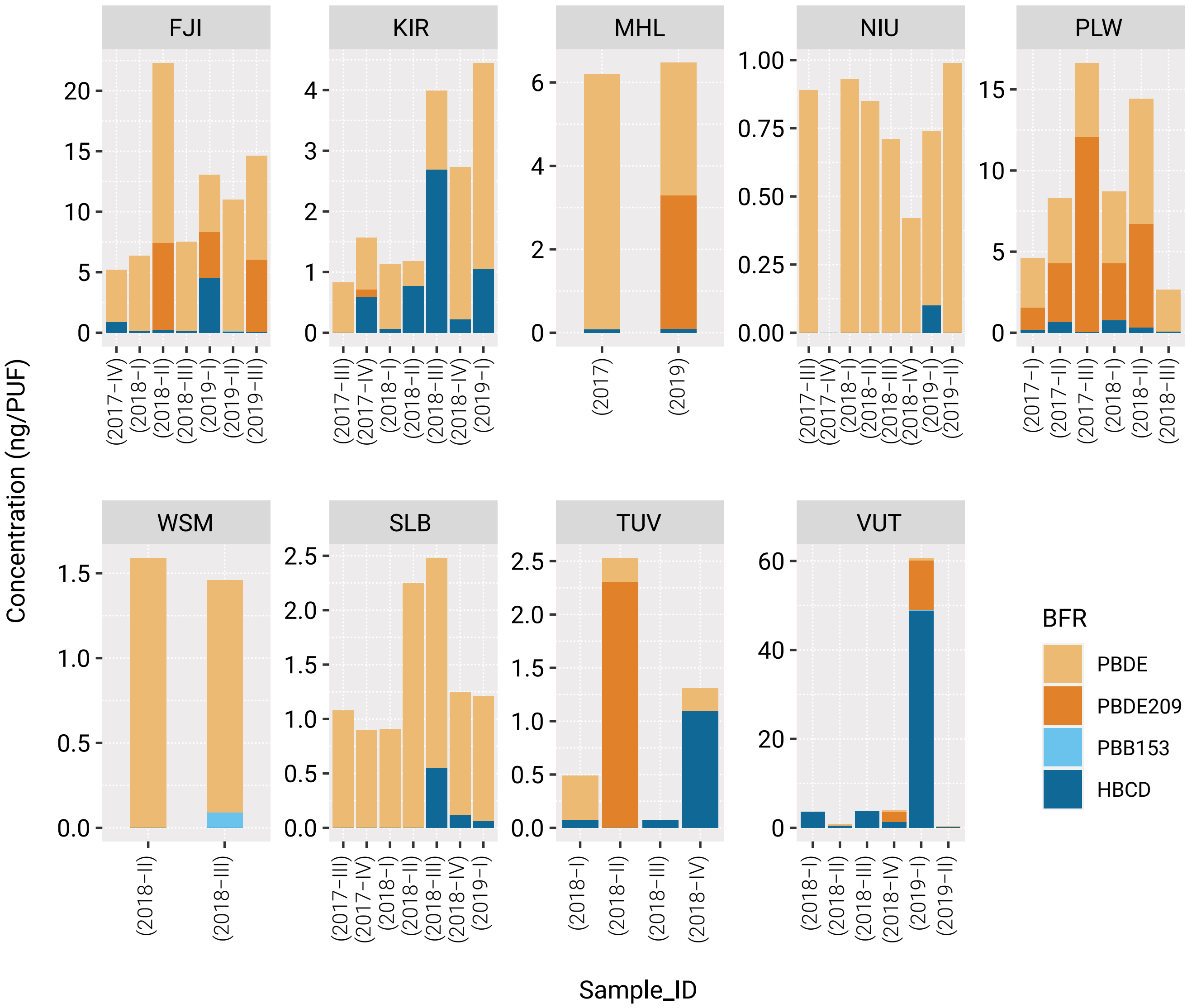


Figure 15: PAS/PUF: Stacked bar graphs for brominated POPs by country and sample (n=49)

Table 9: Brominated POPs in PAS/PUF: Mean (with standard deviation, SD), median, minimum and maximum values (ng/PUF)

POPs	Central tendencies	FJI (N=7)	KIR (N=7)	MHL (N=2)	NIU (N=8)	PLW (N=6)	WSM (N=2)	SLB (N=7)	TUV (N=4)	VUT (N=6)	Overall (N=49)
PBDE	Mean (SD)	8.15 (3.73)	1.48 (1.07)	4.65 (2.08)	0.679 (0.330)	4.41 (1.79)	1.48 (0.156)	1.34 (0.533)	0.218 (0.172)	0.270 (0.251)	2.52 (3.11)
	Median [Min, Max]	7.37 [4.31, 14.9]	1.07 [0.410, 3.40]	4.65 [3.18, 6.12]	0.780 [0, 0.990]	4.25 [2.59, 7.70]	1.48 [1.37, 1.59]	1.13 [0.900, 2.25]	0.225 [0, 0.420]	0.290 [0, 0.660]	1.08 [0, 14.9]
PBDE209	Mean (SD)	2.83 (3.29)	0.017 (0.045)	1.60 (2.26)	0	4.48 (4.28)	0	0	0.575 (1.15)	2.22 (4.40)	1.31 (2.82)
	Median [Min, Max]	1.90 [0, 7.20]	0 [0, 0.120]	1.60 [0, 3.20]	0	3.55 [0, 12.0]	0	0	0 [0, 2.30]	0 [0, 11.0]	0 [0, 12.0]
PBB153	Mean (SD)	0.014 (0.038)	0	0	0	0	0.045 (0.064)	0	0	0.038 (0.094)	0.009 (0.038)
	Median [Min, Max]	0 [0, 0.100]	0	0	0	0	0.045 [0, 0.090]	0	0	0 [0, 0.230]	0 [0, 0.230]
HBCD	Mean (SD)	0.849 (1.64)	0.769 (0.931)	0.085 (0.007)	0.014 (0.035)	0.330 (0.315)	0	0.104 (0.202)	0.308 (0.523)	9.67 (19.2)	1.50 (6.97)
	Median [Min, Max]	0.130 [0.040, 4.50]	0.590 [0, 2.69]	0.085 [0.080, 0.090]	0 [0, 0.100]	0.225 [0.040, 0.770]	0	0 [0, 0.550]	0.070 [0, 1.09]	2.45 [0.150, 48.8]	0.090 [0, 48.8]

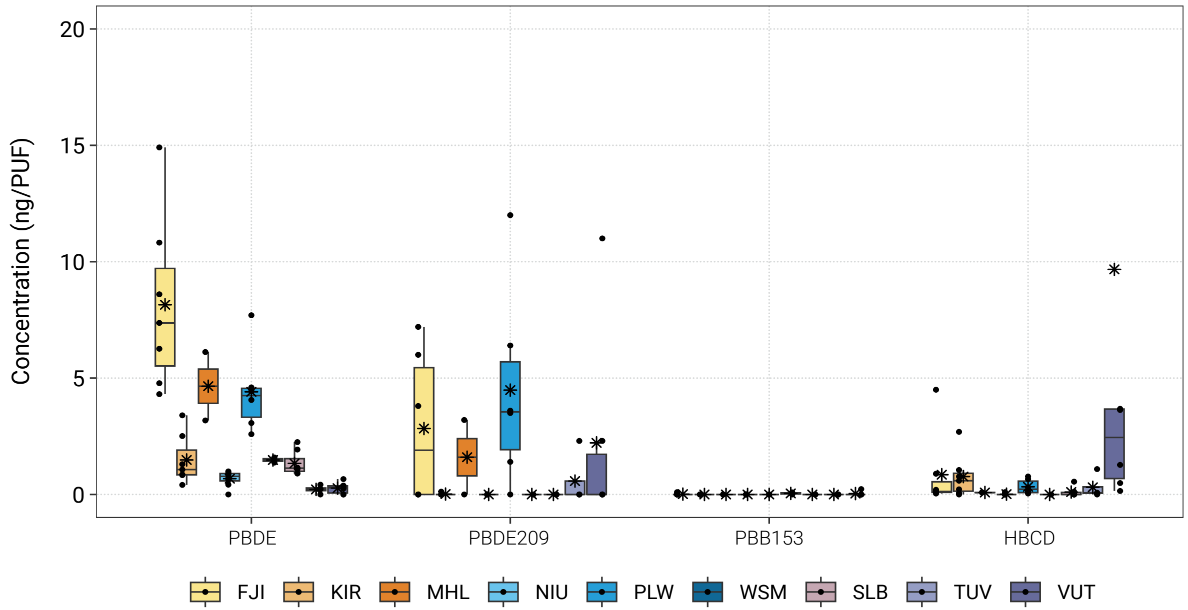


Figure 16: PAS/PUF: Box plots for brominated POPs: summary across all samples (n=49)

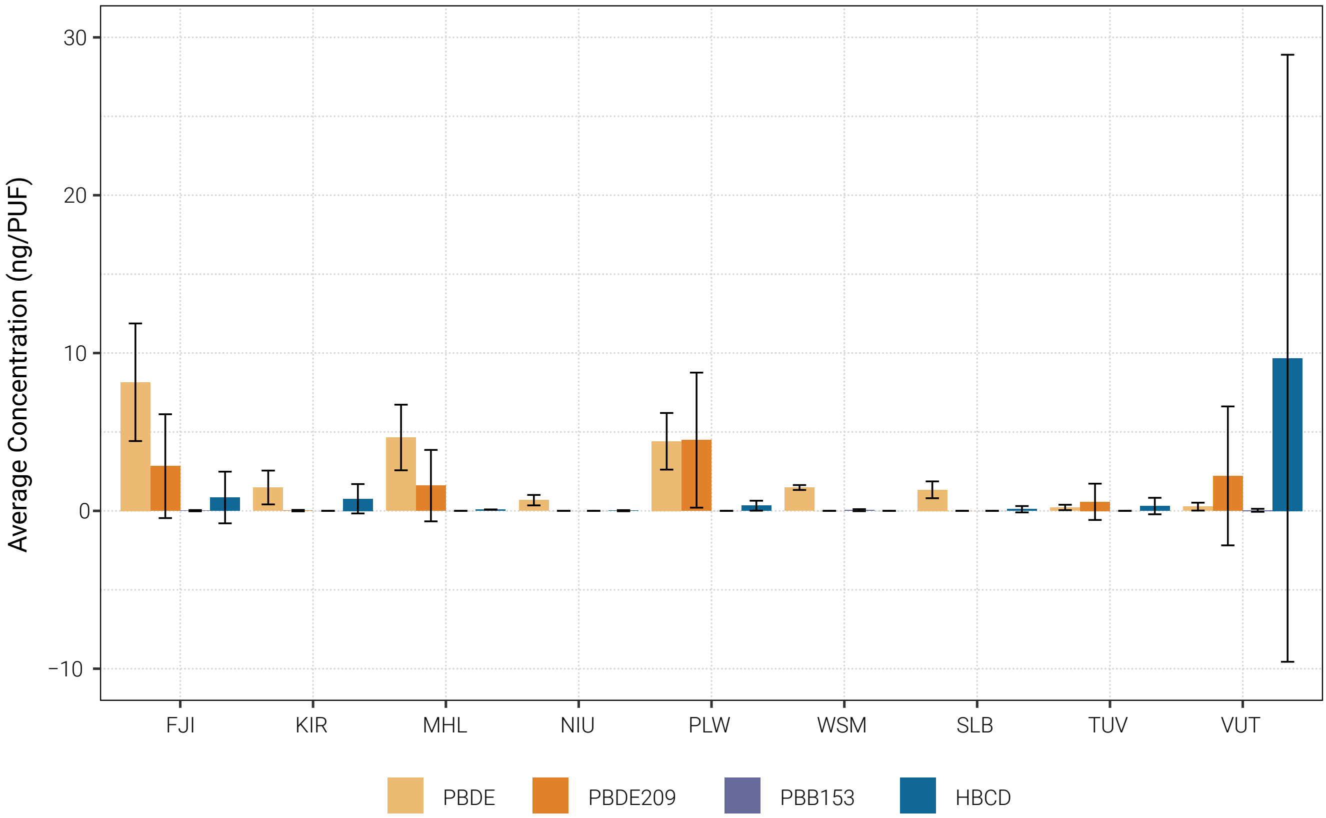


Figure 17: PAS/PUF: Mean values and SD for brominated POPs (n=49)

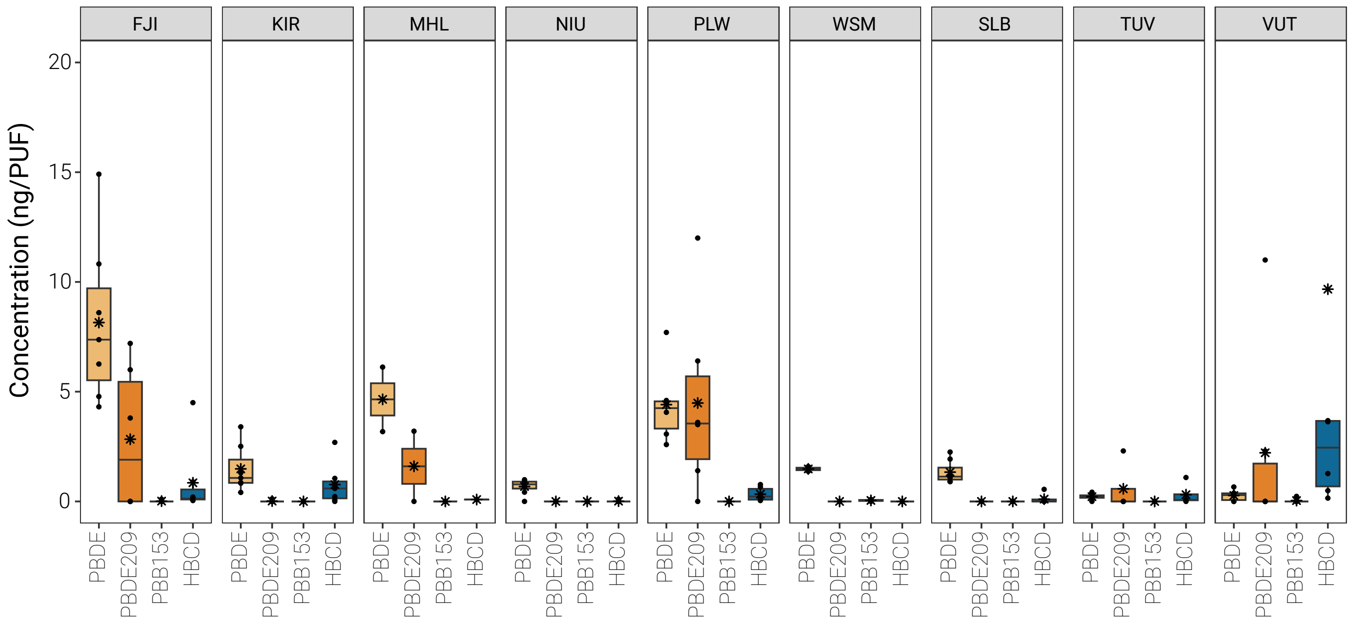


Figure 18: PAS/PUF: Unscaled boxplots for brominated POPs per country; y-axis zoomed to 20 ng/PUF. Concentrations in ng/PUF (n=49)

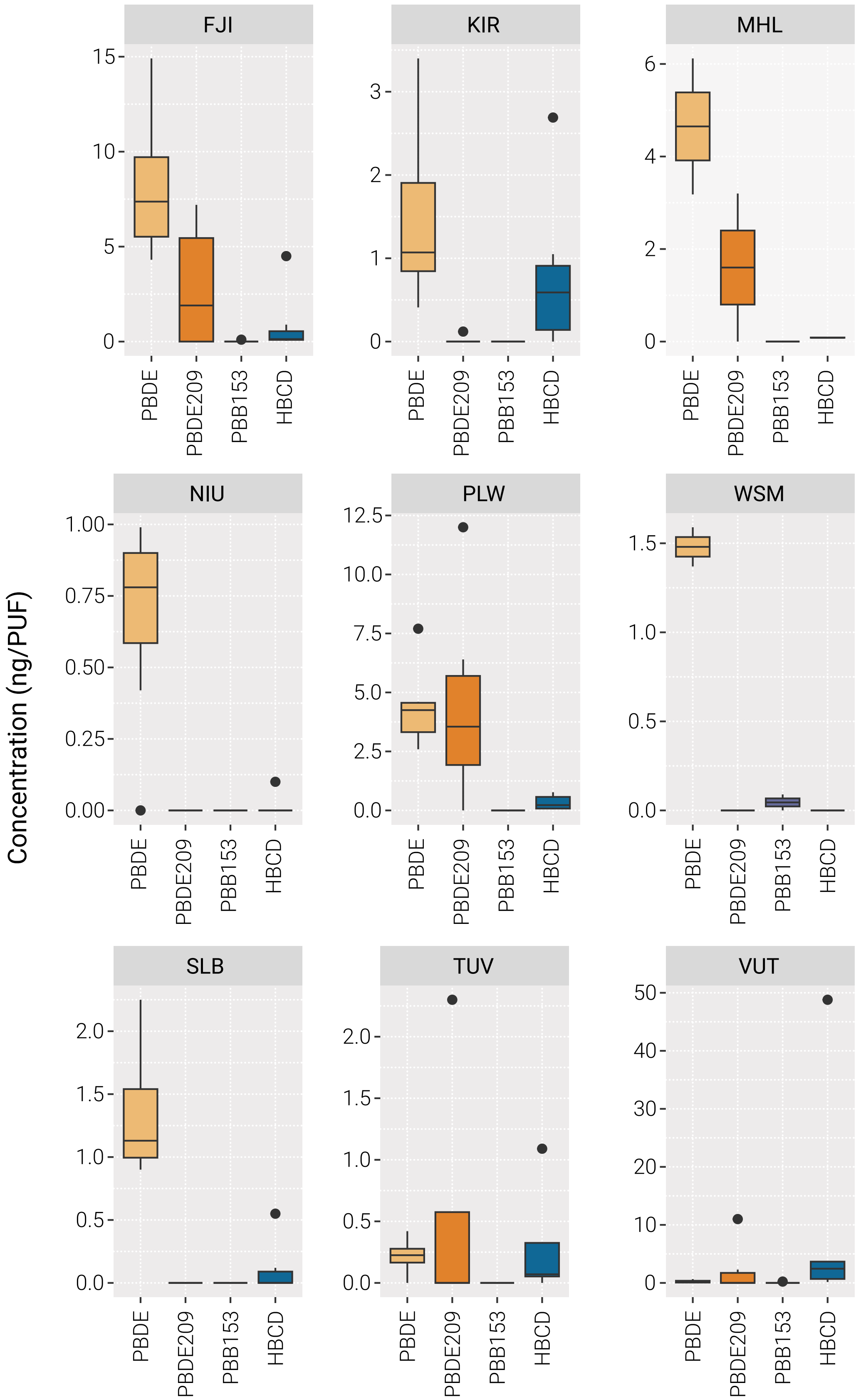


Figure 19: PAS/PUF: Scaled boxplots for sums of brominated POPs by country(n=49)

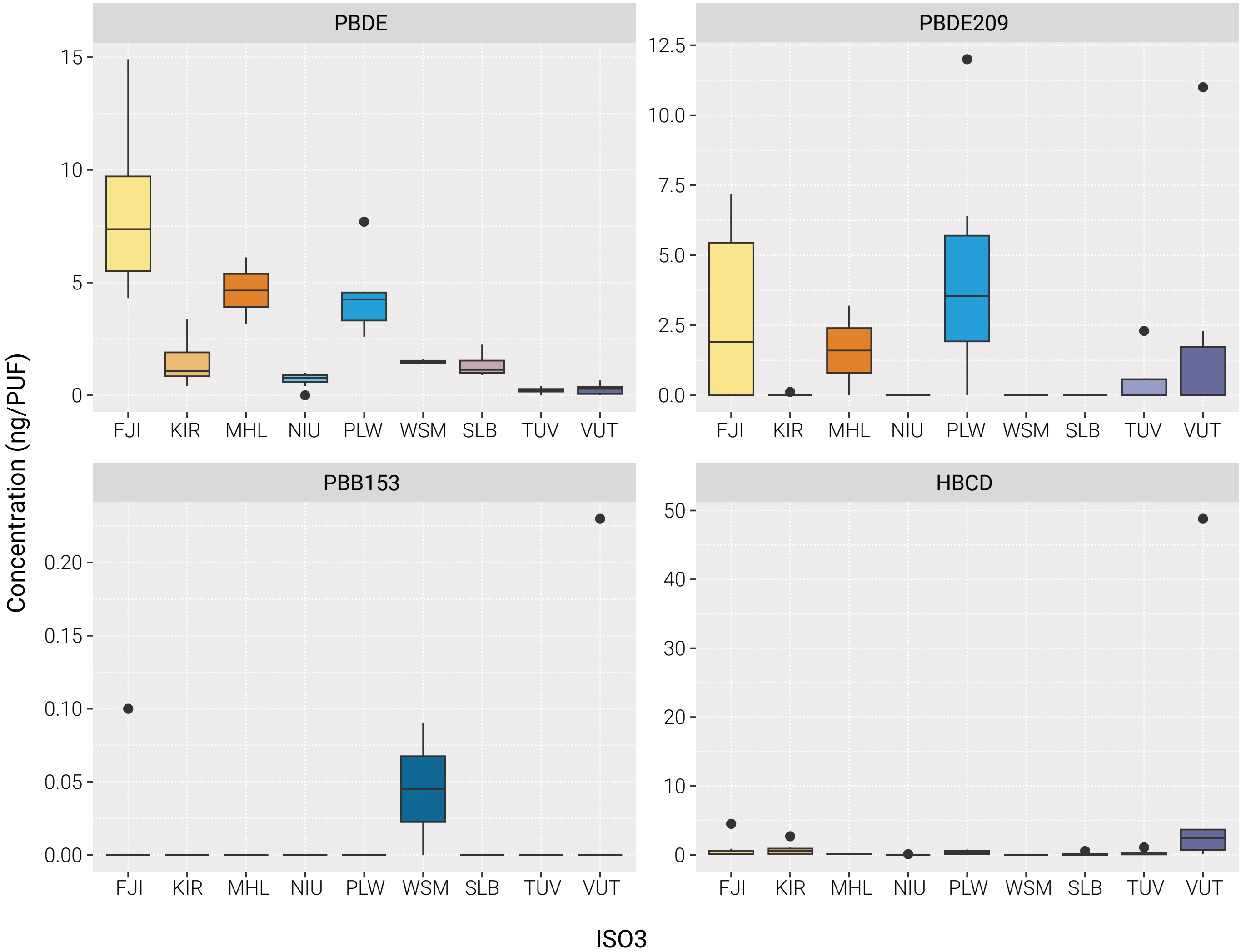


Figure 20: PAS/PUF: Scaled boxplots for country by brominated POPs (n=49)

4.2.4. Perfluorinated POPs

43 samples were received and analyzed (Table 10). Noteworthy that WSM did not send any methanol pretreated PUFs for PFAS analysis.

The summary of the results is contained in Table 11. In 20 PUFs, FOSA could not be determined due to interferences in the chromatogram.

Table 10: PAS/PUFs: Overview of samples analyzed for PFAS by year of sampling

	2017 (N=15)	2018 (N=26)	2019 (N=2)	Overall (N=43)
FJI	1	4		5
KIR	3	5		8
MHL	1			1
NIU	2	3	1	6
PLW	5	3		8
WSM				
SLB	3	5		8
TUV		3		3
VUT		3	1	4

Graphical sketches provide the summary and comparison of results of chemical analyses for the four PFAS. For each country, the results are displayed in Figure 21, showing the total of the three PFAS in stacked bars colored by the individual compounds. The overview on the amounts PFAS found in Pacific Islands samples is shown as box whisker plots in Figure 22. All data refer to 1 PUF and 3 month of exposure time and are given in pg/PUF. The mean values with SD are displayed in Figure 23.

Figure 24 shows the box plots for each country with an unscaled y-axis to capture the scale in each country whereas Figure 25 displays the same information but scaled to the country. Finally, Figure 26, displays for each of the four PFAS the concentrations in each country with box plots. It can be seen that highest PFOS median values were found in Tuvalu, followed by Kiribati, and Niue whereas highest PFOA was found in Kiribati, followed by Tuvalu and Palau. Niue had the highest values for PFHxS and for FOSA.

Between countries, Kruskal-Wallis chi-squared = 7.7456, df = 6, p-value = 0.2573; thus, no significant differences between countries. Pairwise values were between p=0.59 and 0.71. There was no statistically significant difference with respect to years.

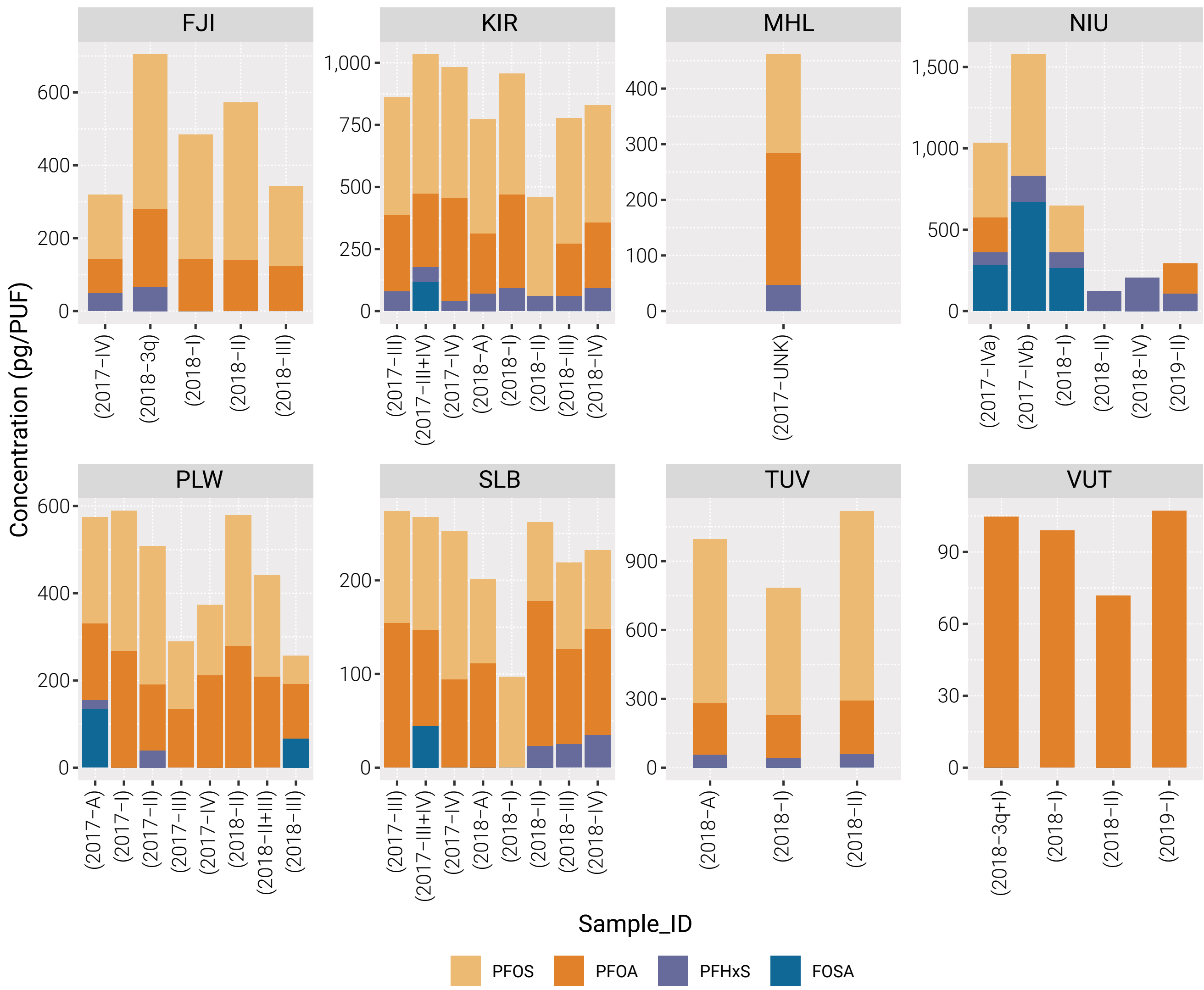


Figure 21: PAS/PUF: Stacked bar graphs for PFAS POPs by country and sample (n=43)

Table 11: Four PFAS in PAS/PUF: Mean (with standard deviation, SD), median, minimum and maximum values (pg/PUF)

POPs	Central tendencies	FJI (N=5)	KIR (N=8)	MHL (N=1)	NIU (N=6)	PLW (N=8)	SLB (N=8)	TUV (N=3)	VUT (N=4)	Overall (N=43)
PFOS	Mean (SD)	319 (117)	486 (48.3)	178 (NA)	497 (231)	225 (91.2)	106 (25.6)	699 (137)	0	297 (219)
	Median [Min, Max]	340 [177, 433]	482 [398, 562]	178 [178, 178]	458 [288, 746]	239 [64.6, 321]	94.8 [84.4, 158]	715 [556, 827]	0	266 [0, 827]
PFOA	Mean (SD)	143 (44.5)	302 (73.1)	237 (NA)	134 (117)	194 (58.3)	119 (25.0)	214 (24.9)	95.7 (16.3)	181 (86.5)
	Median [Min, Max]	139 [94.2, 215]	296 [211, 417]	237 [237, 237]	187 [0, 217]	192 [126, 279]	111 [94.0, 154]	224 [186, 232]	102 [71.8, 107]	165 [0, 417]
PFHxS	Mean (SD)	22.8 (31.9)	69.1 (17.6)	46.9 (NA)	129 (47.7)	7.50 (14.8)	10.4 (14.7)	53.1 (8.79)	0	41.6 (48.5)
	Median [Min, Max]	0 [0, 65.6]	65.4 [40.4, 92.0]	46.9 [46.9, 46.9]	115 [78.6, 206]	0 [0, 39.4]	0 [0, 34.7]	56.5 [43.2, 59.8]	0	34.7 [0, 206]
FOSA	Mean (SD)		29.1 (58.1)		202 (265)	100 (48.3)	8.82 (19.7)	0		68.5 (155)
	Median [Min, Max]		0 [0, 116]		132 [0, 669]	100 [66.3, 135]	0 [0, 44.1]	0		0 [0, 669]

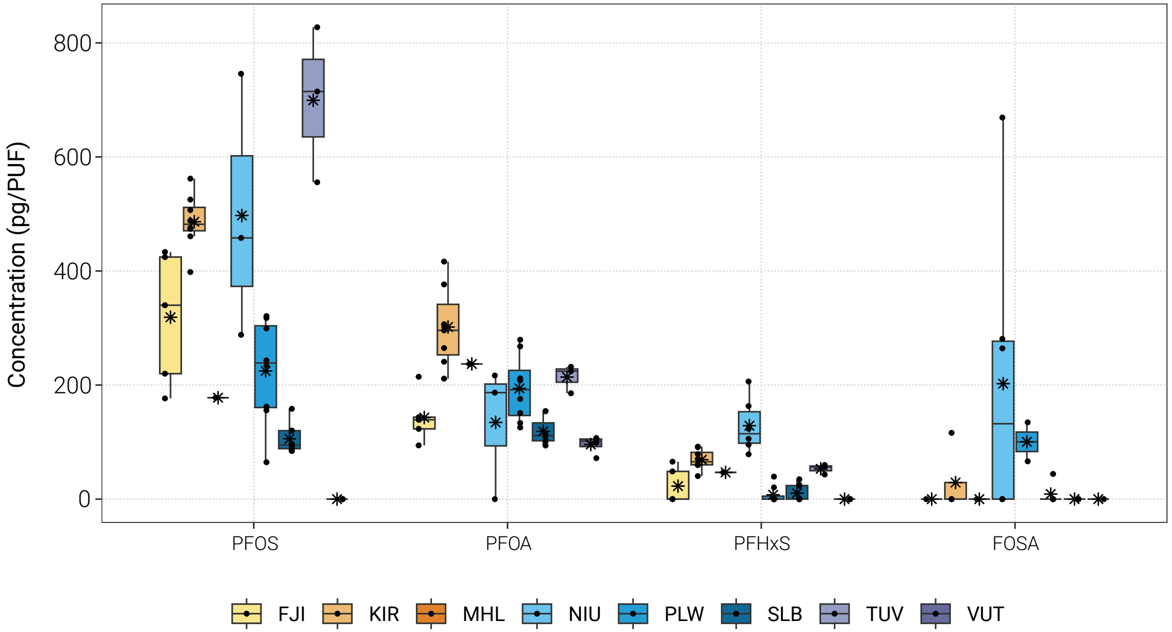


Figure 22: PAS/PUF: Summary of PFAS in PAS/PUFs Box whisker (n=43)

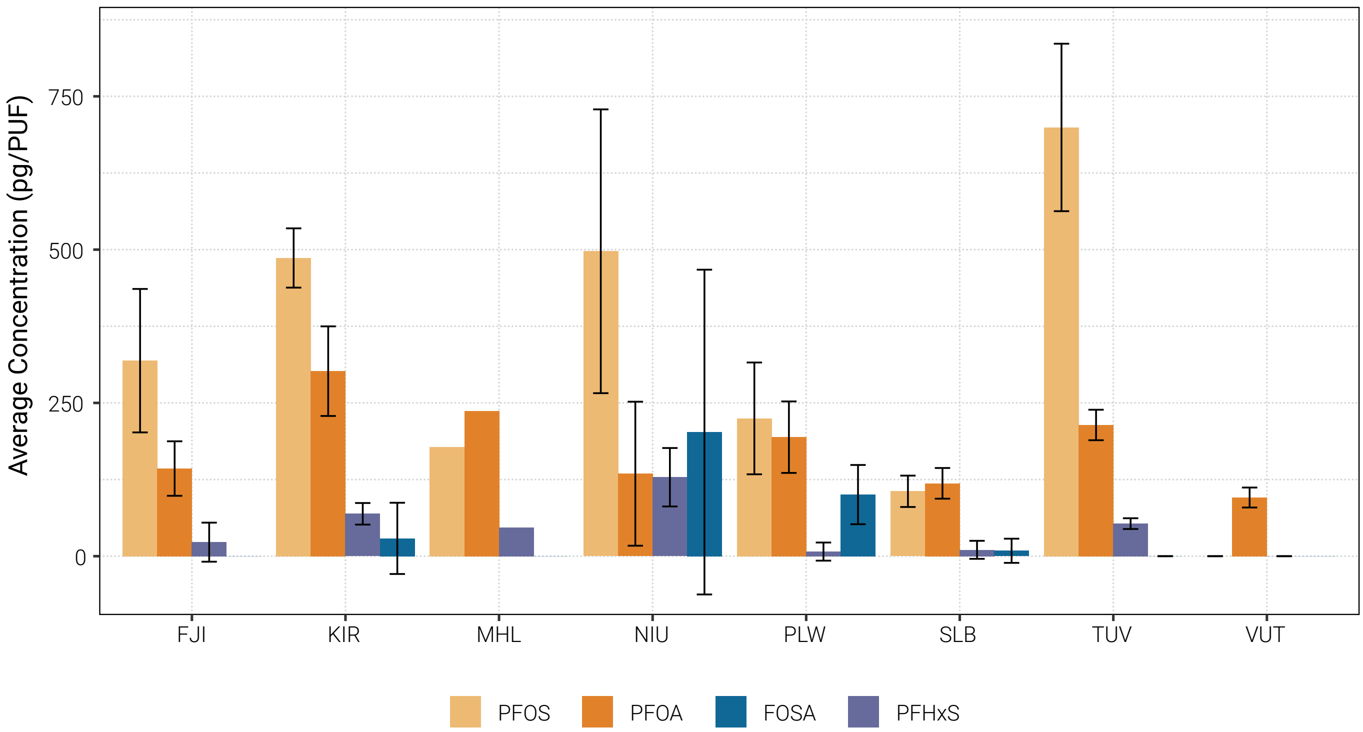


Figure 23: PAS/PUF: Mean values and SD for 4 PFAS (n=43)

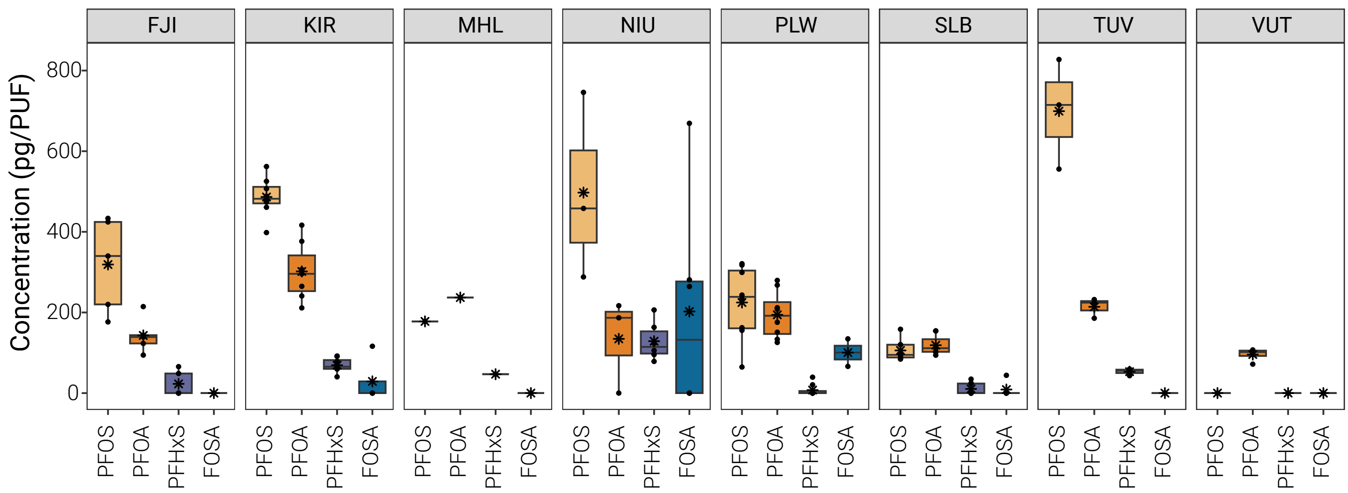


Figure 24: PAS/PUF: Unscaled for concentrations of 4 PFAS in PUFs by country. Y-axis zoomed to 800 pg/PUF (n=43)

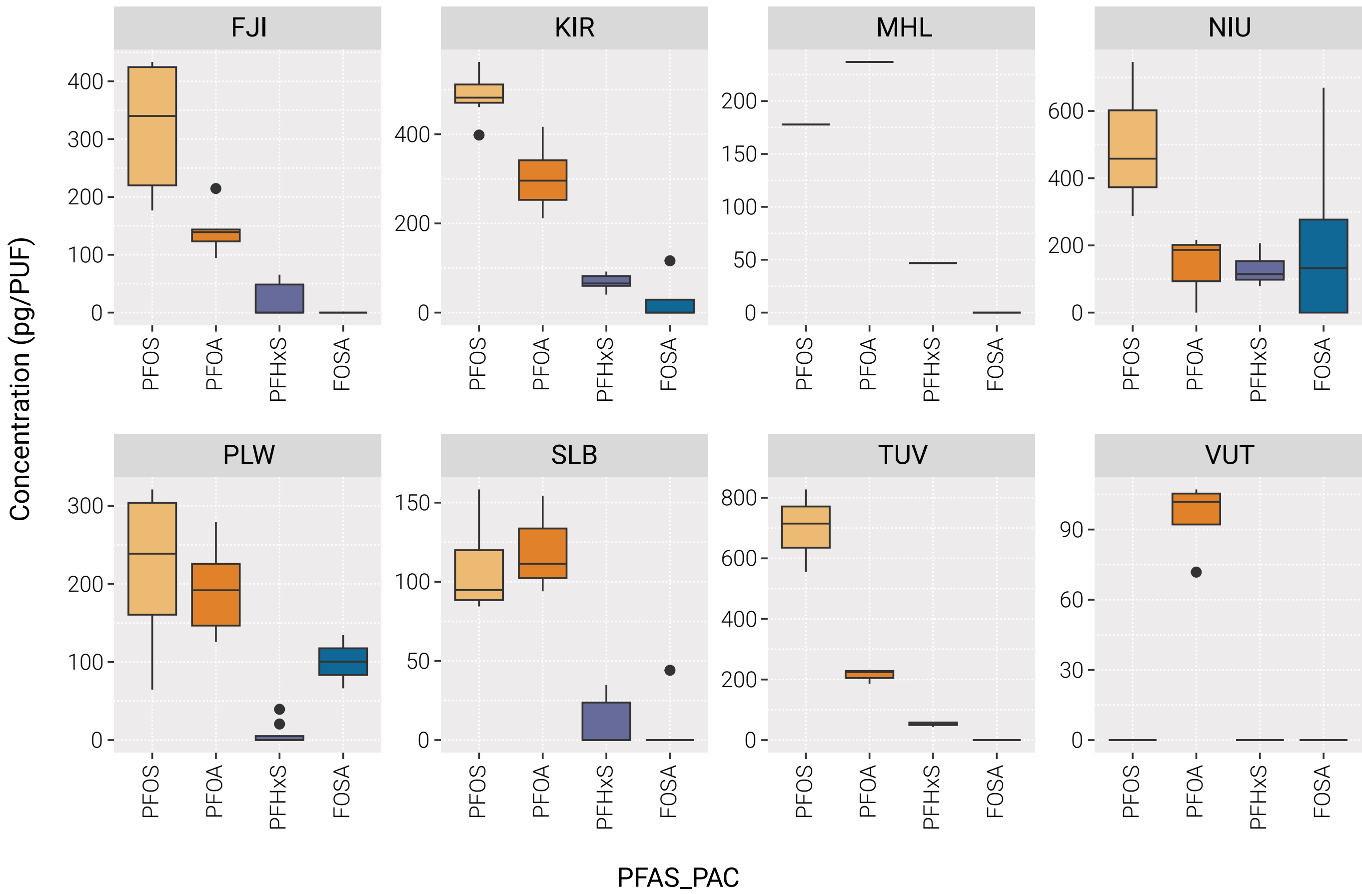


Figure 25: PAS/PUF: Scaled boxplots for concentrations of 4 PFAS by country (pg/PUF) (n=43)

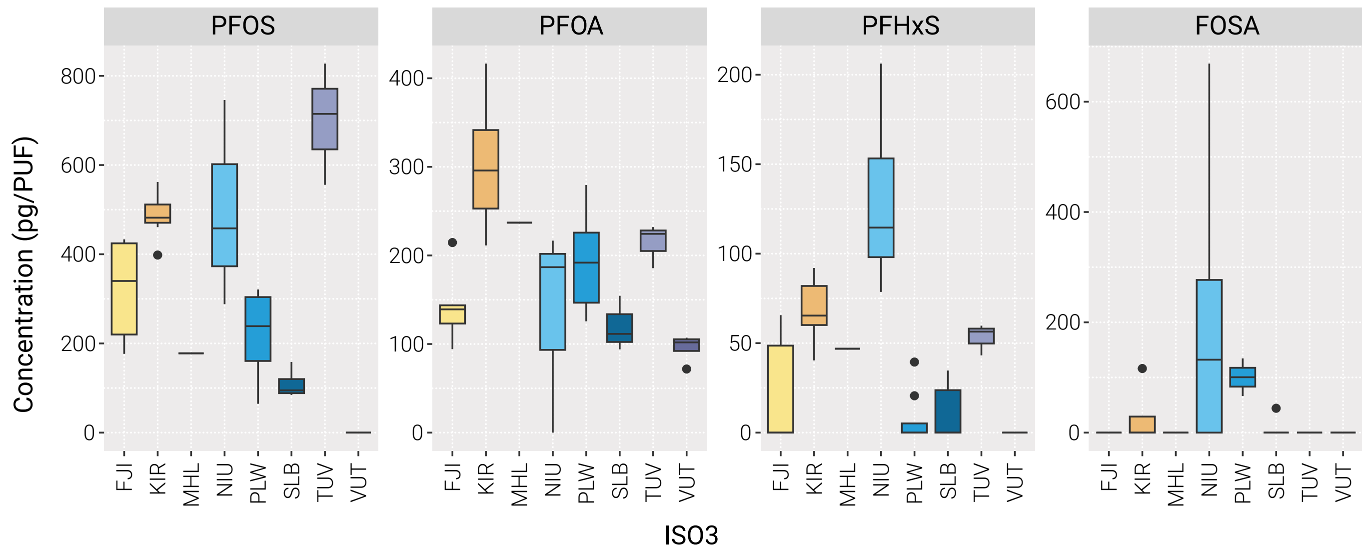


Figure 26: PAS/PUF: Scaled boxplots for concentrations according PFOS, PFOA, PFHxS by country (pg/PUF) (n=43)

4.3. Water

Water is a core matrix for perfluorinated POPs only. We have analyzed 46 water samples for the three PFAS (Table 12). The results of the water samples for the sum of the three targeted PFAS are detailed in Table S 8. Table 13 provides the descriptive statistics for the three PFAS. Overall, the median concentrations of PFOS and PFOA were similar and PFHxS was about 3-times lower. The mean concentration of PFOS was about 10-times higher than for PFOA.

Figure 28 gives an overview on the PFAS concentrations by country. It can be clearly seen that the highest concentrations were found in Vanuatu, where mean and median values were much higher than in all other countries. Vanuatu had also the maximum values for PFOS, PFOA, and PFHxS.

Table 12: PFAS in water: overview on samples

	2017 (N=14)	2018 (N=28)	2019 (N=4)	Overall (N=46)
FJI	2	3		5
KIR	2	4	1	7
MHL		4		4
NIU	1			1
PLW	4	2		6
WSM	1	4	1	6
SLB	2	4		6
TUV	1	3		4
VUT	1	4	2	7

Scale and composition of all samples analyzed from the Pacific Islands countries are shown as stacked bars in Figure 27. It shall be noted that the single samples from MHL had only one PFAS quantified al levels close to the limit of detection; they can be hardly seen in the graphics.

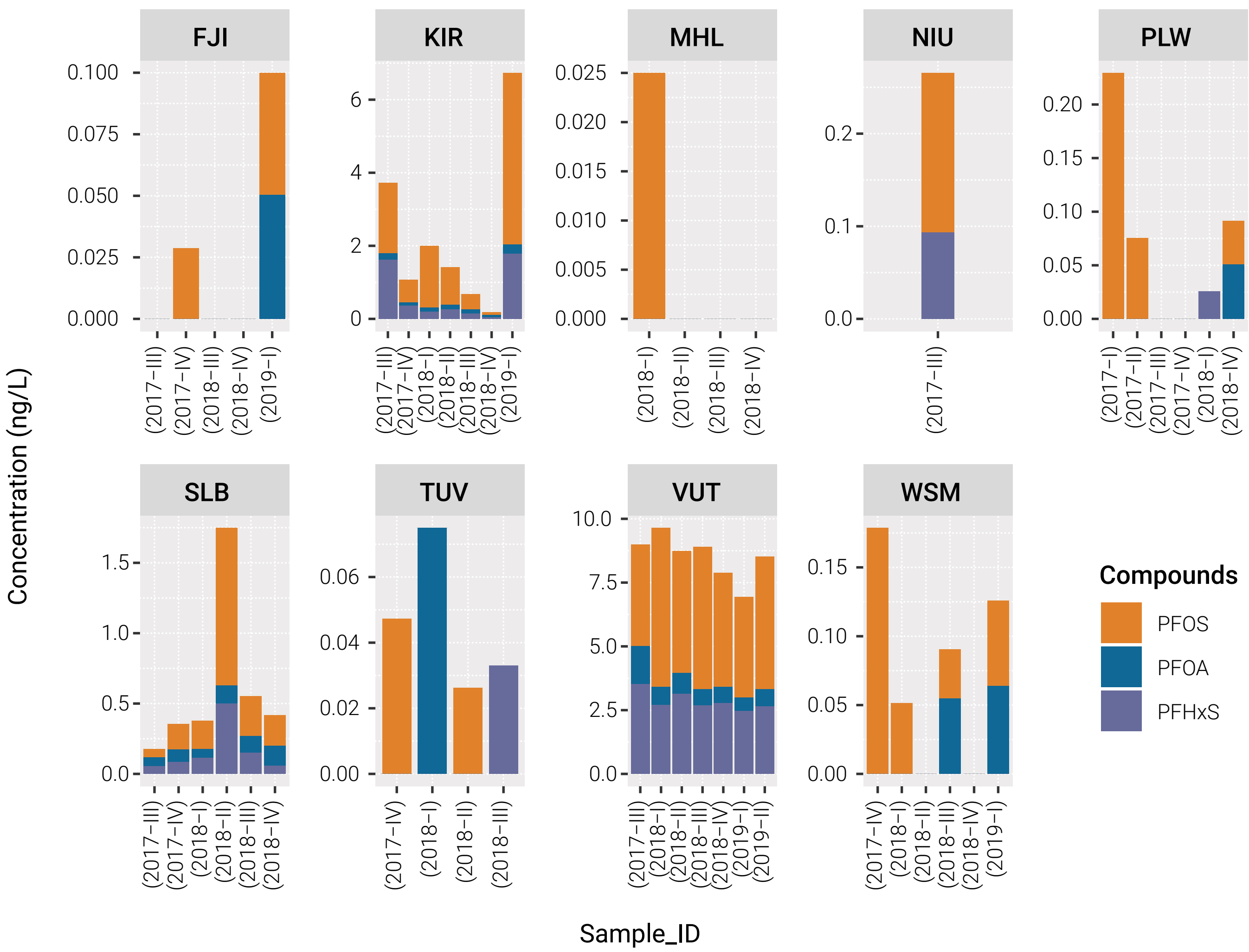


Figure 27: Water: Overview on PFAS concentrations by sample and country (stacked boxplots). Concentrations in ng/L

Table 13: PFAS in water: Mean (with standard deviation, SD), median, minimum and maximum values (ng/L)

POPs	Central tendencies	FJI (N=5)	KIR (N=7)	MHL (N=4)	NIU (N=1)	PLW (N=6)	SLB (N=6)	TUV (N=4)	VUT (N=7)	WSM (N=6)	Overall (N=46)
PFOS	Mean (SD)	0.016 (0.023)	1.49 (1.56)	0.006 (0.014)	0.172 (NA)	0.058 (0.090)	0.344 (0.388)	0.018 (0.023)	4.88 (0.843)	0.055 (0.066)	1.04 (1.85)
	Median [Min, Max]	0 [0, 0.050]	1.03 [0.080, 4.70]	0 [0, 0.025]	0.172 [0.172, 0.172]	0.021 [0, 0.229]	0.208 [0.061, 1.12]	0.013 [0, 0.048]	4.77 [3.94, 6.23]	0.044 [0, 0.179]	0.069 [0, 6.23]
PFOA	Mean (SD)	0.010 (0.023)	0.134 (0.060)	0 (0)	0 (NA)	0.008 (0.021)	0.102 (0.0336)	0.019(0.038)	0.795 (0.326)	0.0197 (0.0307)	0.161 (0.302)
	Median [Min, Max]	0 [0, 0.050]	0.119 [0.066, 0.247]	0 [0, 0]	0 [0, 0]	0 [0, 0.051]	0.105 [0.063, 0.143]	0 [0, 0.075]	0.681 [0.539, 1.51]	0 [0, 0.0638]	0.052 [0, 1.51]
PFHxS	Mean (SD)	0 (0)	0.631 (0.741)	0 (0)	0.093 (NA)	0.004 (0.011)	0.159 (0.170)	0.008 (0.017)	2.84 (0.359)	0 (0)	0.552 (1.05)
	Median [Min, Max]	0 [0, 0]	0.257 [0.041, 1.79]	0 [0, 0]	0.093 [0.093, 0.093]	0 [0, 0.026]	0.098 [0.053, 0.498]	0 [0, 0.033]	2.69 [2.46, 3.51]	0 [0, 0]	0.013 [0, 3.51]

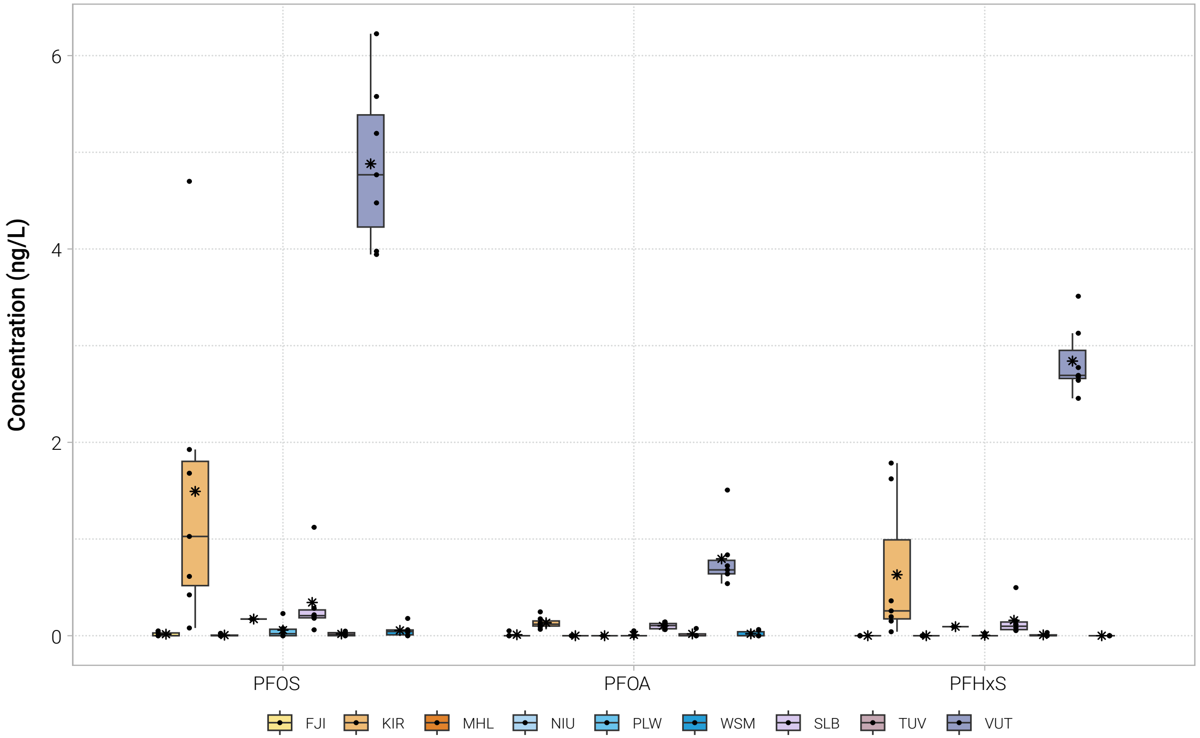


Figure 28: Water: Overview on PFAS concentrations in the Pacific Islands region. Concentrations in ng/L

The mean values with SD are shown in Figure 29. The comparison of results of chemical analyses for PFAS as unscaled and scaled boxplots for each country are shown in Figure 30 and Figure 31. Figure 32 provides an overview for each of the three PFAS.

Statistically, there were significant differences between all countries, p=<2.2 $\times 10^{-16}$. Pairwise significant differences were identified between Vanuatu and all other countries. In addition, the Kiribati samples also showed many statistically significant differences (see also Figure 29)

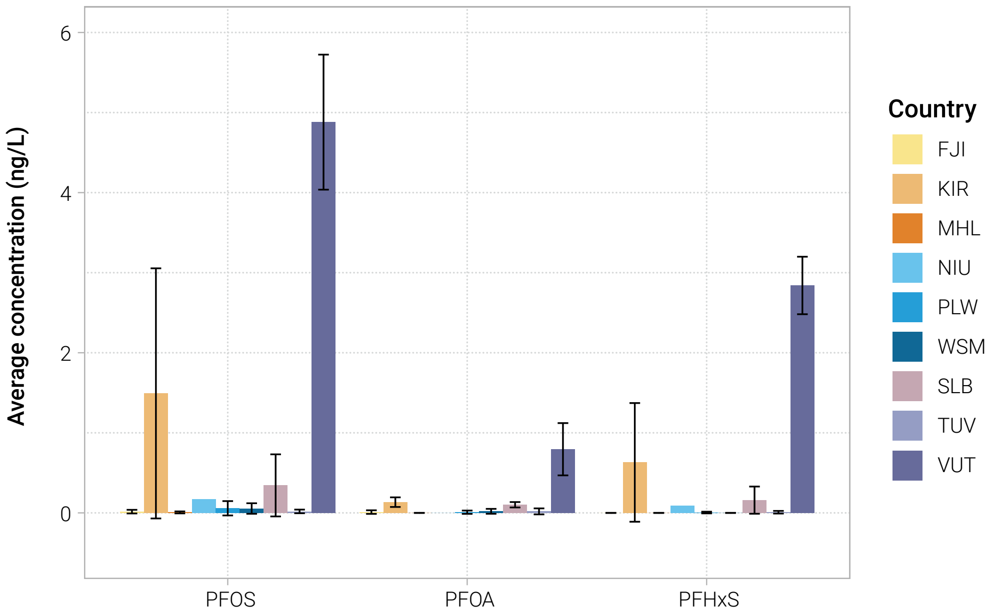


Figure 29: Water: Mean values and SD for three PFAS (n=46)

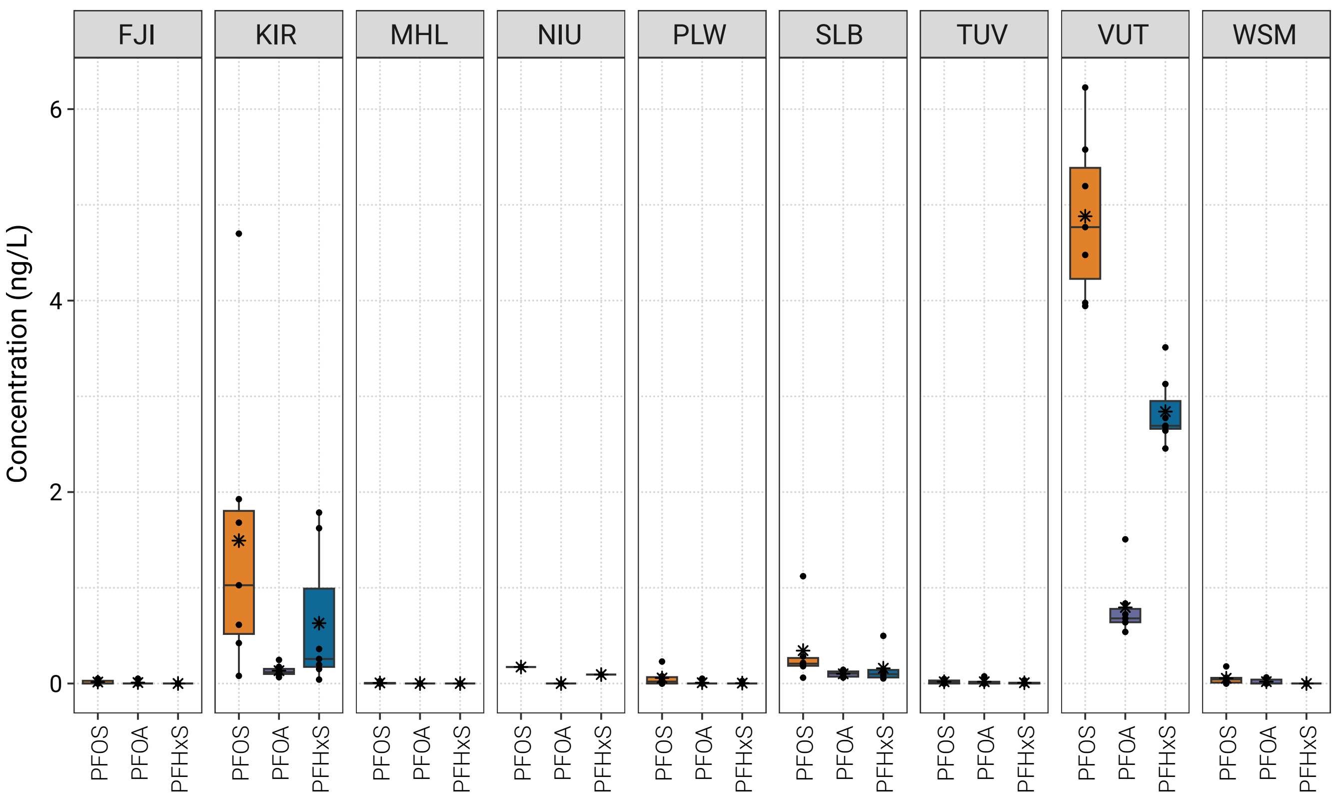


Figure 30: Water: Unscaled boxplots of 3 PFAS by country

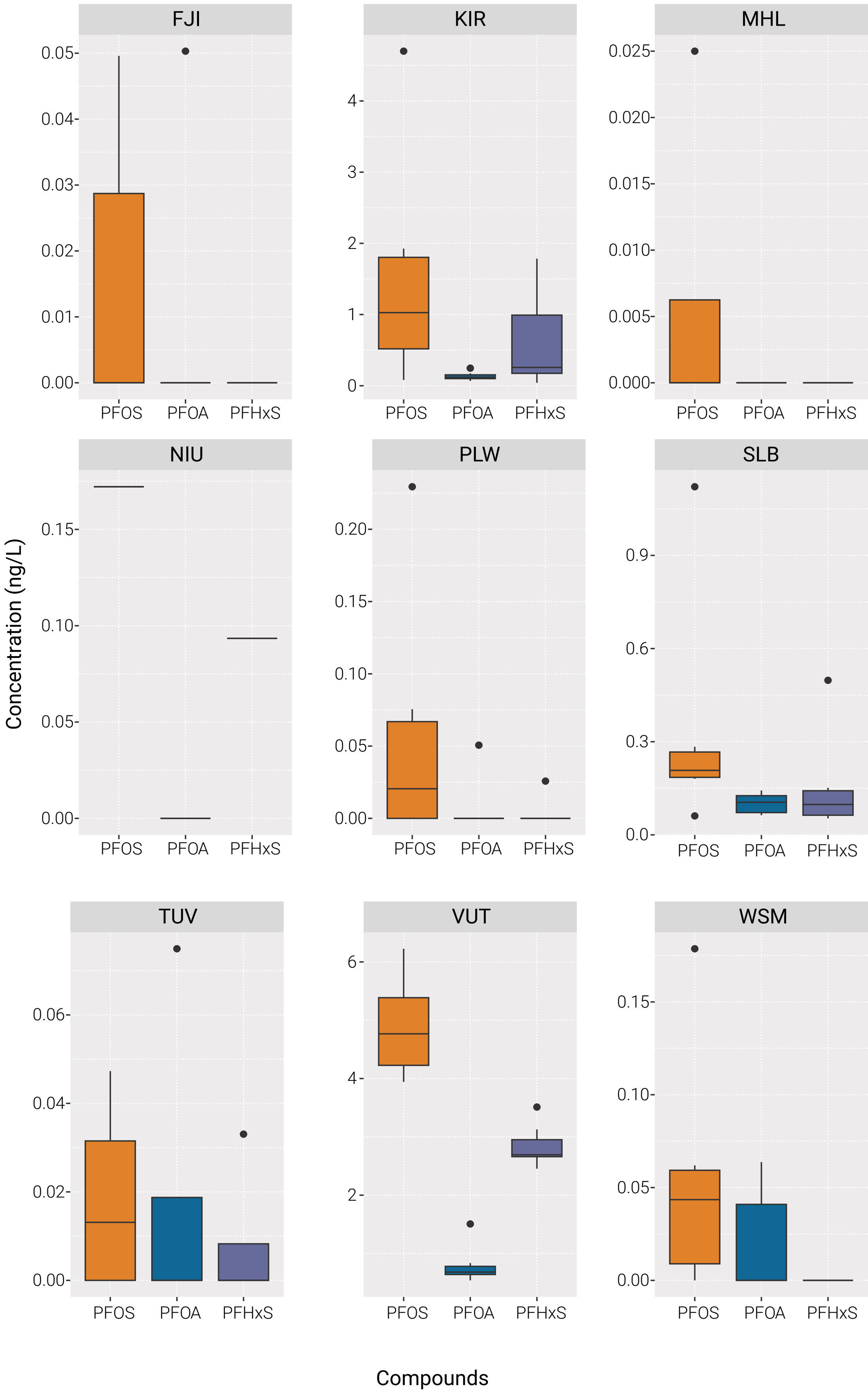


Figure 31: Water: Amounts according PFOS, PFOA, PFHxS by country and year (ng/L)

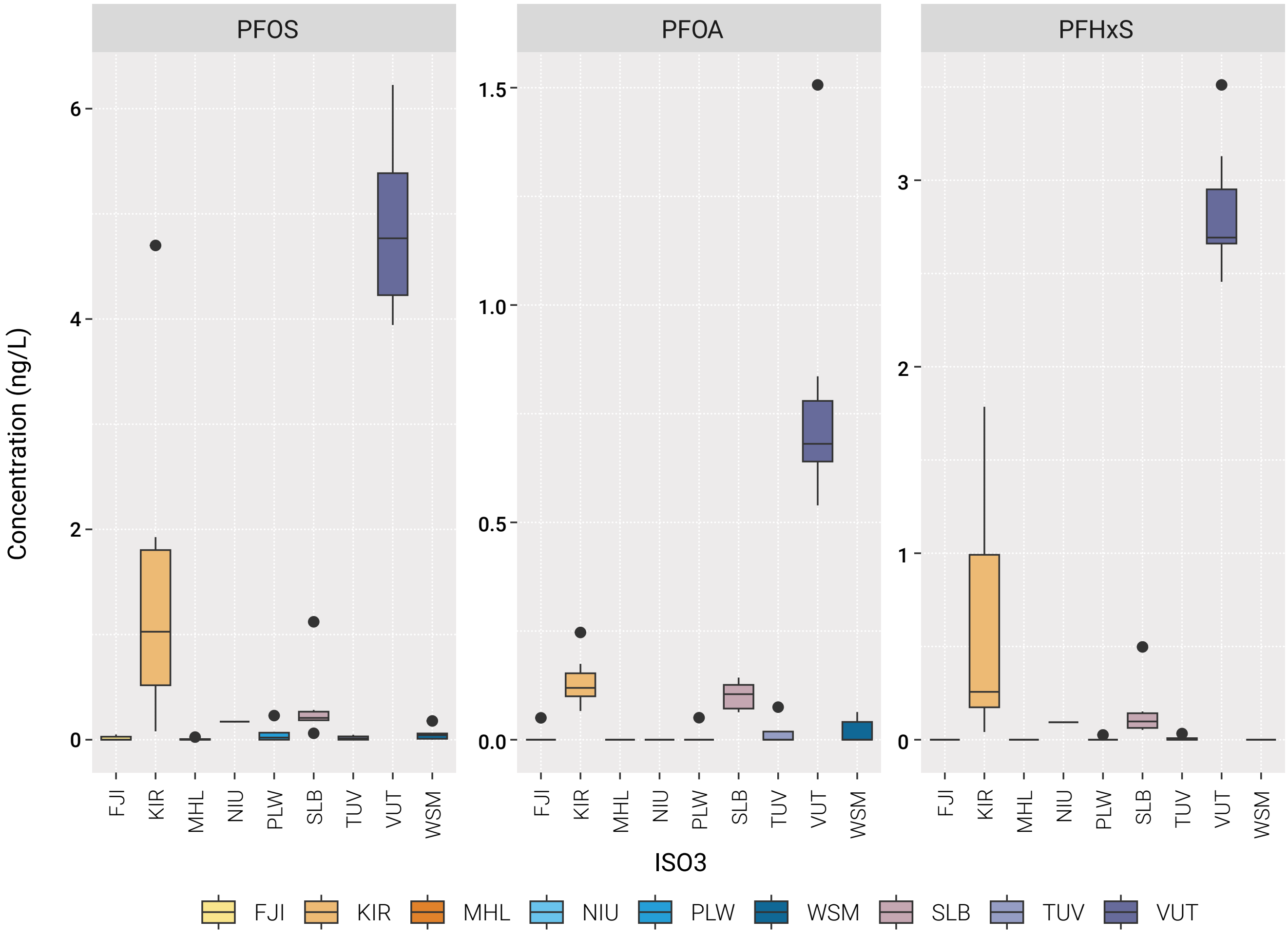


Figure 32: Water: Comparison of values for each country for PFOS, PFOA, PFHxS concentrations (ng L^{-1}) according to Year

4.4. Human milk

Human milk samples were analyzed by CVUA in Freiburg, Germany, for chlorinated and brominated POPs and by Örebro University for PFAS. All participating countries except Tuvalu submitted national pools. The Tuvalu pool was created but due to erroneous management, it was lost before shipment. Niue sent a second pool for PFAS analysis in 2019.The descriptive statistics for the quantified POPs are shown in Table 14.

Adrin, endrin, mirex, endosulfan, PeCBz, and HCBD were not quantified above the LOD in any of the nine national pools. They are not included in the tables and figures. Three POPs were quantified only once, namely, α-HCH in the pool from the Solomon Islands, PBB 153 in Samoa, and PFHxS in Kiribati.

The results of the individual measurements by POP are visualized as barplots in Figure 33.

Among the chlorinated POPs, DDT had the highest concentrations with the maximum found in the pool from the Solomon Islands (1253 ng/g lipid) (Figure 34). Also, SCCP showed high values especially in Kiribati and Samoa. $PBDE_6$ were highest in the Marshall Islands, also PBDE 209. From the heptachlors, only cis-heptachlorepoxide was quantified, and only in the Marshall Islands. MHL also had the highest concentrations of PCB_6, $PBDE_6$, PBDE 209 and TEQs. PLW had the highest concentrations for chlordane, α-HCH, and HCB. KIR had the highest values for SCCPs, PFOS, PFOA, and PFHxS. WSM was high for α-HBCD.

With respect to dl-POPs, the TEQs from PCDD/PCDF (TEQ_DF) were always higher than the TEQ from dl-PCB (TEQ_PCB) (Figure 35). The highest values for TEQ_DF and TEQ_PCB were found in MHL.

Brominated POPs were predominantly found in the Marshall Islands and Samoa (Figure 36).

PFOS and PFOA were found in all countries with the exception of PFOS in Fiji that was below the LOQ. PFHXs was detected in one sample from KIR; the amount of PFHxS was the highest across all samples analyzed in the four regional projects (Figure 37).

Table 14: Human milk: Results for quantified POPs in national pools (OCPs and BFR in ng/g lipid, dl-POPs in pg TEQ/g lipid, PFAS in pg/g f.w.)

POPs	FJI (2019)	KIR (2018)	MHL (2019)	NIU (2017)	NIU (2019)	PLW (2018)	WSM (2019)	SLB (2019)	VUT (2018)
dieldrin	1.79	<LOD	0.82	3.16		1.38	0.91	0.87	1.83
chlordane	<LOD	<LOD	0.89	<LOD		1.21	<LOD	<LOD	<LOD
DDT	97.2	79.4	30.5	170		66.8	115	1253	121
heptachlor	<LOD	<LOD	0.63	<LOD		<LOD	<LOD	<LOD	<LOD
toxaphene	<LOD	<LOD	<LOD	<LOD		<LOD	0.53	1.73	<LOD
α-HCH	<LOD	<LOD	<LOD	<LOD		<LOD	<LOD	2.30	<LOD
β-HCH	1.81	1.53	<LOD	0.70		6.48	0.53	1.73	1.03
lindane	2.50	<LOD	<LOD	<LOD		0.61	2.57	3.46	<LOD
PCB6	4.45	6.00	23.4	4.52		8.61	5.68	2.55	3.61
HCB	2.65	3.00	2.78	2.30		4.98	2.57	3.46	2.06
SCCP	70.2	188	86.0			24.2	175	107	69.3
PBDE	0.12	0.79	11.0			1.99	0.73	2.45	0.33
PBDE 209		0.18	5.92				3.31	0.23	1.62
HBCD	<LOD	0.80	<LOD	<LOD		0.20	1.60	0.40	0.30
PBB 153	<LOD	<LOD	<LOD	<LOD		<LOD	1.68	<LOD	<LOD
TEQ_DF	2.19	1.92	9.32	1.29		2.63	2.30	1.73	1.43
TEQ_PCB	0.71	1.13	2.29	0.47		0.97	1.00	0.74	0.52
PFOS	<6.2	212	12.9	21.6	24.9	9.49	26.0	15.3	9.18
PFOA	10.2	31.8	12.9	17.1	10.0	20.2	21.5	11.5	11.2
PFHxS	<5.5	111	<5.5	<5.5	<5.5	<5.5	<5.5	<5.5	<5.5

Note: Empty cells indicate that the respective POP was not analyzed

Photo: ©Pexels / Pixabay

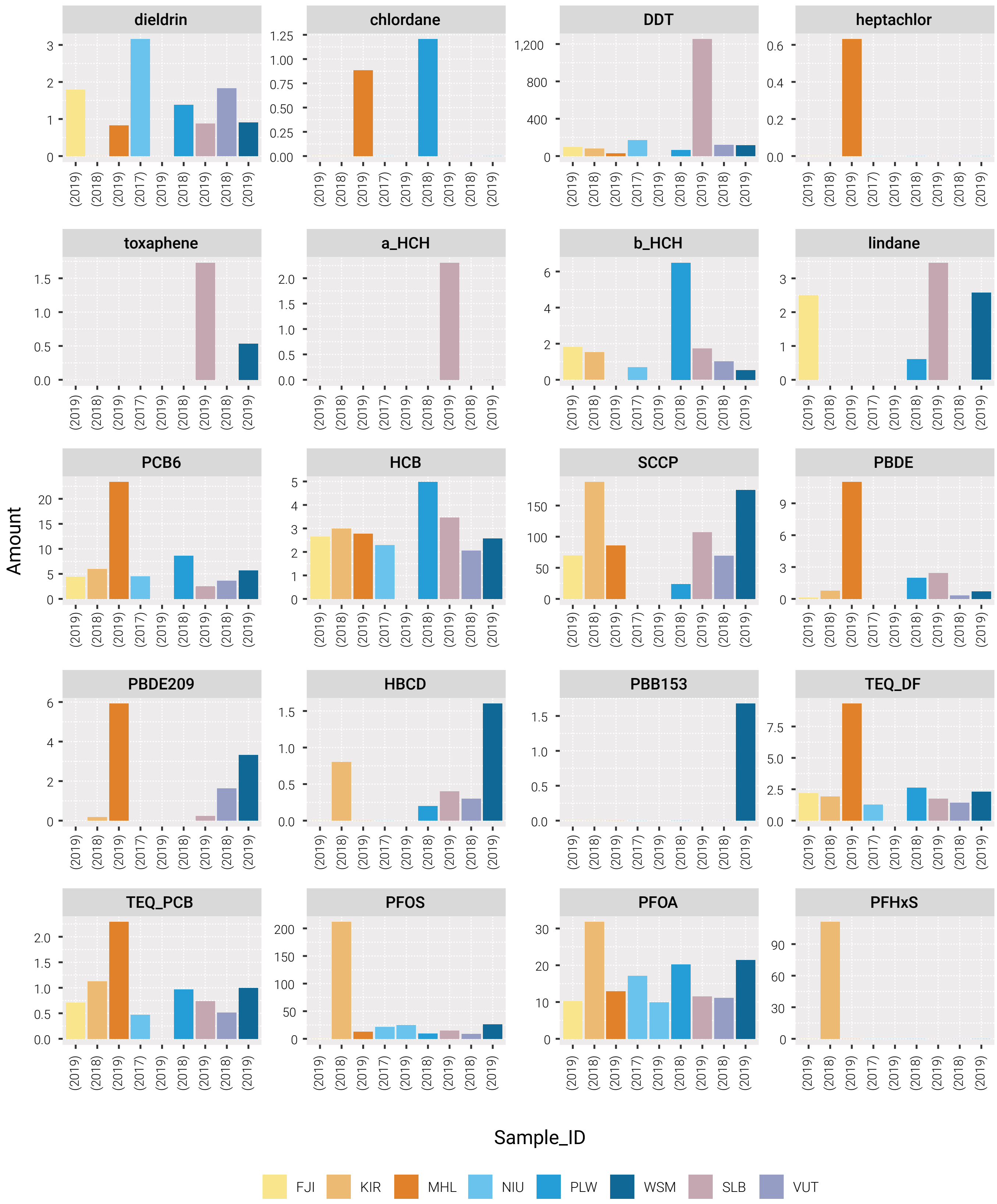


Figure 33: Human milk: Scaled barplots by POPs with concentrations by country (pg TEQ/g lipid for the dl-POPs, pg/g f.w. for PFAS; all other in ng/g lipid)

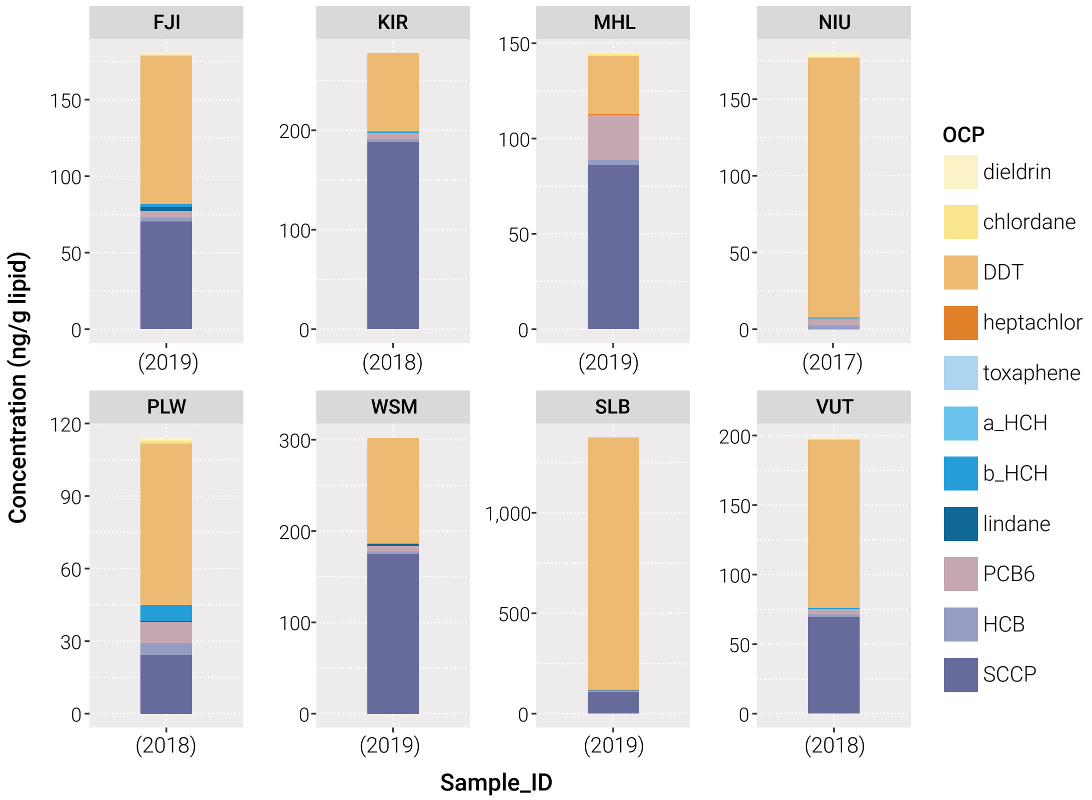


Figure 34: Human milk: Stacked bars for chlorinated POPs by country (ng/g lipid)

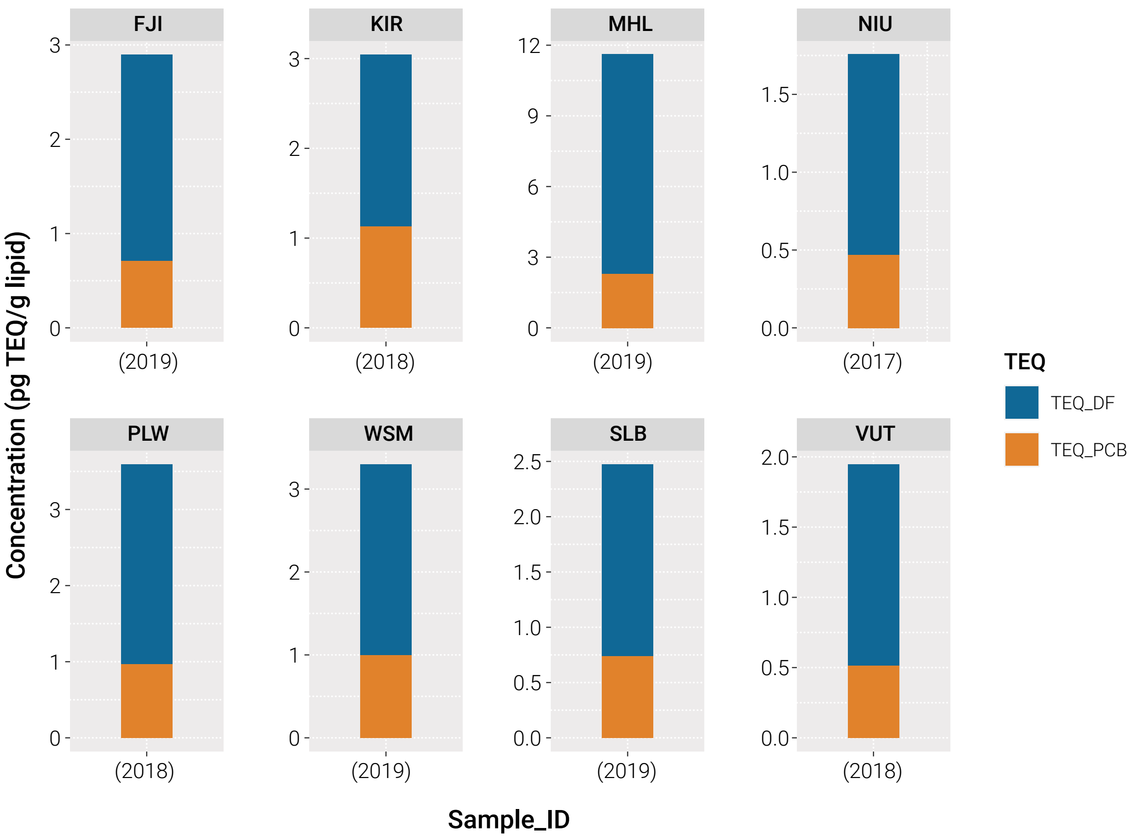


Figure 35: Human milk: Stacked bars for dl-POPs (pg TEQ/g lipid)

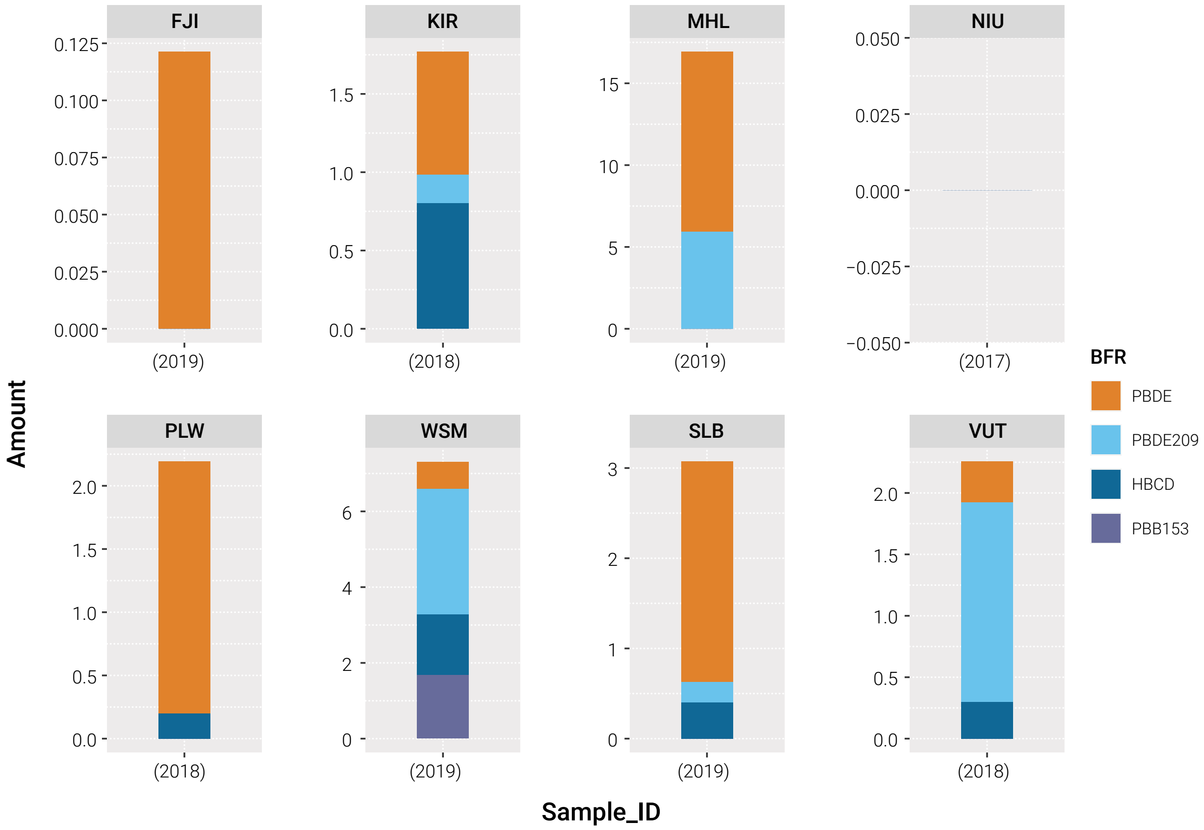


Figure 36: Human milk: Stacked bars for brominated POPs by country (ng/g lipid)

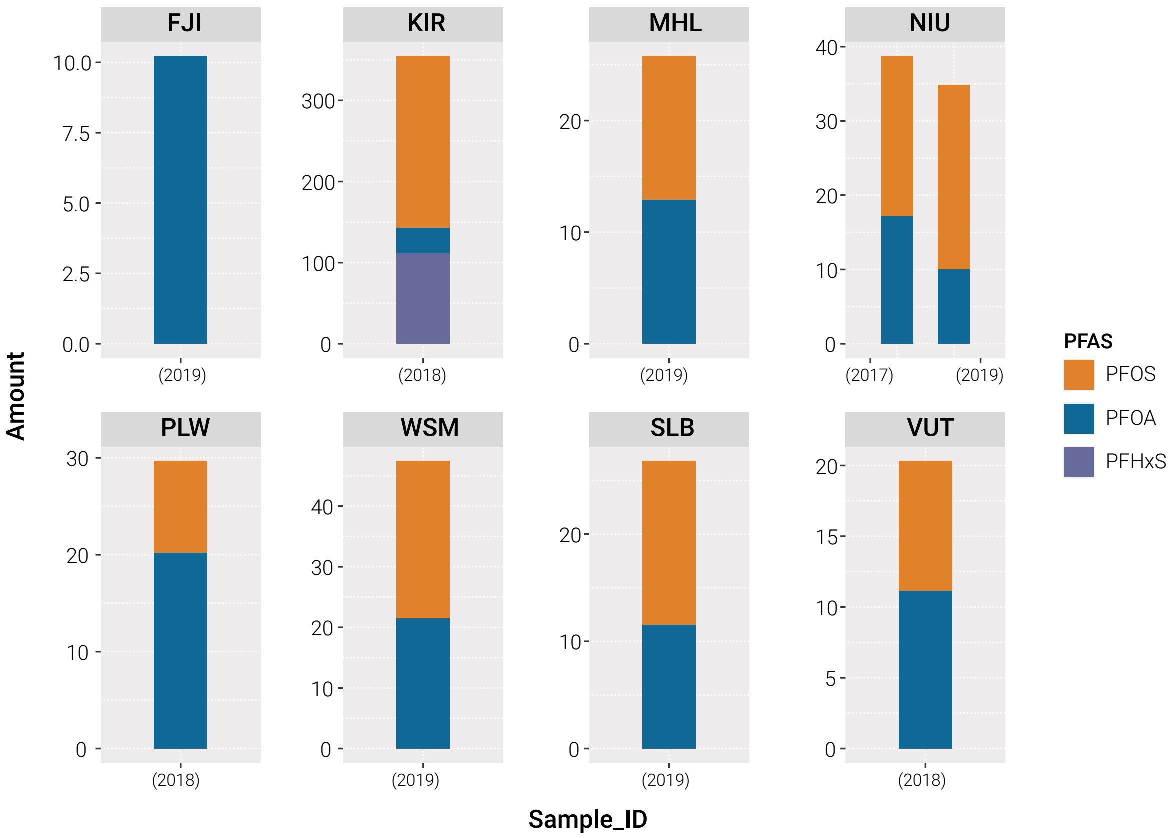


Figure 37: Human milk: Stacked bars for PFAS by country (pg/g f.w.)

SECTION 5

Capacity building activities and regional workshops

Photo: ©UNEP / Jitendra Sharma

5. CAPACITY BUILDING ACTIVITIES AND REGIONAL WORKSHOPS

Activities related to the two rounds of interlaboratory assessments, are referred to in a separate report (UNEP 2023a).

As much as possible, countries are encouraged to promote gender-responsive capacity building in line with the SDGs, the GEF gender policy, the Paris Agreement as well as various other international agreements.

5.1. Inception regional workshop

The inception workshop for the UNEP/GEF project in the Pacific Region and the training workshop of the UNEP/GEF project on "Global Project on the Updating of National Implementation Plans for POPs" were held on from4 to 8 April 2016 in Suva, Fiji. The workshops mainly delivered the following outputs:

- Good understanding of the context of the project, including the effectiveness evaluation of the Stockholm Convention and the outcomes of the GMP1 regional project in the Pacific Region
- Clarification of the roles and responsibilities of the participating countries and institutions
- Increased familiarity with the set-up, workplan, timeline, budget and activities of the GMP2 project, including air sampling and analysis, human milk sampling and laboratory training
- Discussion and finalization of the drafted legal agreements between UNEP and the participating countries.

Documents, presentations and the report of the workshop are available on the UNEP website (UNEP 2016).

5.2. Mid-term regional workshop

The midterm workshop of the GEF-funded project in the Pacific Region was held on 17-18 September 2018 in Brisbane, Australia.

The midterm workshop aimed to strengthen communication among core partners on the progress of the 2nd phase POPs global monitoring plan (GMP2) in the Pacific Region, and to discuss about future needs, opportunities and challenges beyond GMP2, as well as the sustainable monitoring of POPs on nation, regional and global level.

Documents, presentations and the report of the workshop are available on the UNEP website (UNEP 2018).

5.3. Regional results workshop for air and water

The regional results virtual meeting for Air and Water of the GEF/UNEP GMP2 project in the Pacific Region was held on 8 October 2020. The main objectives of the meeting were:

- Explain the analytical results on the levels of POPs in air and water shared with project countries.
- Provide clarifications on data, if any.
- Discuss on including the data in national project final reports

5.4. Laboratory trainings

Under the GEF GMP2 projects, one-week training on the analysis of core media is provided to national laboratories in 9 countries. Due to COVID-19, some planned trainings could not be conducted, and a few others were delivered virtually. As of February 2022, two scheduled trainings had been completed with nine countries participating (Table 15).

Table 15: Trainings in project countries planned and progress made.

Region	No. of trainings planned	No. of trainings conducted	No. of countries participated	No. female participants	No. male participants
Pacific Islands	2	2*	9	6	6

* Note: Upon request, the planned laboratory training in the Pacific Islands region was converted into a hands-on course in air and water sampling for all nine participating countries complemented by theoretical lectures.

5.5. Knowledge transfer and training

As part of the project, Queensland Alliance for Environmental Health Sciences (QAEHS) from the University of Queensland, Australia, was contracted to provide knowledge transfer and training to the University of the South Pacific (USP) team. Staff from USP received training on the LC-MS/MS at the QAEHS premises from 10 to 14 February 2020.

QAEHS donated a LC-MS/MS instrument and consumables such as columns, tubing for LC-MS instrument to USP. At USP, a method for analysis of PFAS was set up. Örebro University donated native and labelled analytical standards developed for the GMP2 projects and a freeze-dried fish test material to USP to strengthen their PFAS analysis.

SECTION 6

Sustainability plans

Photo: ©UNEP / Víctor Estellano

6. SUSTAINABILITY PLANS

6.1. Involvement in other monitoring activities and networks

The data generated under this project by either the national POPs laboratories or the expert laboratories were made available for the gmp data warehouse maintained by Recetox at Masaryk University.

The expert laboratories – VU Vrije universiteit Amsterdam, CSIC or MTM Research Centre Örebro University – did submit their results to UNEP Environment & Health Branch in the units as shown in chapter 5.

6.2. Planed activities

QAEHS has contacted three national coordinators, Vincent Lal (Fiji), Roselyn Bue (Vanuatu) and Debra Kereseka (Solomon Island), to discuss their potential for deploying and collecting passive samples for PFAS analysis. They agreed to provide a list of potential sampling sites and other samples of interest such as air and food samples that can contribute for GMP. Once agreed on sampling sites, passive sampler kits will be shipped to each country. All other national coordinators will be contacted in the future to collect matrices of major national interest from Pacific Island countries.

Detailed description and the results of the activities undertaken and contribution to the future regional monitoring plan, are referred to in a separate document.

6.3. National sustainability plans

The following national sustainability plans are an extract of the plans submitted by project countries in their national reports.

6.3.1. Fiji

To continue monitoring until a follow-up GMP study, USP is continuing PAS/PUF and surface water sampling activities in Fiji in collaboration with QAEHS. USP IAS is also working with Conservation International to identify POPs monitoring areas in Fiji which are also relevant to conservation-related activities (*i.e.*, ambient air and water quality to protection of native species). It is important to build critical mass of support for POPs monitoring in Fiji and successful implementation on the GMP in Fiji.

6.3.2. Palau

While there is interest in continuing data collection in Palau, the current capacity for monitoring and analysis does not exist and cannot be developed without external technical and financial support. The possibility of expanding national capabilities to conduct the analysis here can be done in conjunction with Palau Community College, however the associated costs is not something that can be covered by the government right now due to limited funding and capacity. There is interest in developing laboratory capacity within Palau to be able to conduct laboratory analysis of POPs within Palau. This will enable Palau to conduct more sampling and testing of air, water, and breastmilk. While it is understood that the cost of starting up a laboratory to test for these POPs may be expensive, should there be continued support from the established laboratories to continue providing sampling equipment and analysis, Palau may be able to continue with sampling of air and water.

Palau continues to be interested in the sampling of biological matrices, which unfortunately were not collected for the GMP2 due to Covid-19 related delay issues.

6.3.3. Solomon Islands

The sustainability of such projects and activities related to POPs in the county is directly related to the national implementation plan (NIP). The development of the NIP is first toward sustainable solutions for POPs in the country. The presence of POPs in human milk samples and the detection of new POPs, such as PBDE, HBCD, PFOS, PFOA, SCCP measured for the first time in 2019 demonstrate the need for the NIP to be implemented.

The full implementation of the NIP will require additional financial and technical resources. The Environment and Conservation Division as the lead coordination agency is working with other partners to establish the coordination mechanism for chemicals that will encompass POPs for a start. Further work will be done to address key priorities identified under this project.

6.3.4. Tuvalu

The national implementation plan (NIP) 2019 is an updated version of the old NIP in 2008, to take into considerations of the new POPs being added under the Annexes of the Stockholm convention. The NIP document provides a framework plan in terms of managing and reducing POPs in Tuvalu. It is also in-line with the convention especially contributing and complying with Article 7 of the Convention.

In addition, the DOE also have its draft NEMS (2022-2030) where it focuses on different aspects of the Environment – climate change, land management, marine management, biodiversity conservation, waste management, chemical management, built environment, culture, heritage and awareness, and environmental governance. These nine thematic areas mainly emphasize various action plans in the healing and restriction process of the environment.

Moreover, there are also plans for the respective officer (Chemical Management Officer) in the DOE to ensure that POPs and chemicals are well monitored, controlled and reduced. For a more elaborative plan, see table below. The overall estimated budget for implementation is $120,000:

6.3.5. Vanuatu

1. Vanuatu has the human resource capacity to collect samples but does not have the specific laboratory with the appropriate equipment and the technical capacity to conduct POPs analyses in addition to financial to conduct the monitoring.

2. Vanuatu's updated NIP for POPs does include monitoring of POPs.

3. To sustain the monitoring of POPs, financial assistance is needed. In addition, technical advice/support and also if a laboratory can be identified in the region and upgraded to accredited standards, then the Pacific Island countries can use that rather than sending samples all the way to Europe for analysis.

4. The updated NIP has used the results from the GMP2 to include the activities for Vanuatu Vanuatu is also in the progress of enacting a legislation for the sound management of chemicals including POPs so the results will contribute to relevant measures for POPs in the legislation.

PRIORITY	ACTIVITIES IDENTIFIED IN WORK PLAN TO ACHIEVE PRIORITIES	EXPECTED RESULTS	IMPLEMENT OFFICIALS
Implementation of Action Plans identified in the NIP review 2019	Awareness Programme Through social media (The department's official facebook page, Radio Tuvalu, workshops/consultation)	To outline the purpose of the NIP Boost capacity building in terms of managing of POPs and unintentional POPs	CMO - Department of Environment
Used Lubricant Oil Sub-Committee Spot Check	Spot check every garage, businesses and government agencies who uses oil	Ensure proper use/managing/handling of used oil, and that are transfer to the Waste Department Transfer Station to avoid future spills.	CMO, Waste Department and Energy Department
PCB Removal	Undertake testing for PCBs in electrical transformers	PCB contaminated oil and equipment removed from the country/identify, label and remove from use equipment containing greater than 10% PCB and volumes than 5 litres.	CMO, PWD - Electrical Department, Waste Department
	Investigate and where necessary, remediate PCB contaminated sites at the Funafuti TEC organization.	Soil contaminated by PCB's are removed from the country	CMO, TEC, PWD - Electrical Department, Waste Department
Identify Contaminated Sites posed by Chemicals or Lubricants	Investigate and where necessary, remediate any contaminated sites at the Funafuti airfield.	Aqueous film forming foam (AFFF) contaminated soil removed from the country	Aviation, Waste Department and Environment Department -CMO
	Remove or transfer all IBCs of used oil to the Waste Transfer Station, and clean contaminated sites.	Less/no oil spill incidents	CMO, Funafuti Kaupule/local council and the Department of Waste Management
To develop a National Chemicals Management Policy and Costed Implementation Plan	Engage with a legal consultant and work collaboratively.	Policy endorsed by the Cabinet (and ready for implementation)	DOE, CMO & legal consultant
	Validation workshop	To outline the purpose of the policy to key stakeholders and even the public	CMO, AG's Office, Department of Waste Management, Department of Health, Department of Agriculture + ULO Committee
Mercury Management	Identify mercury products and develop awareness towards communities	Protects human health and the environment	CMO and the MIA project coordinator
	Capacity building in handling and managing of mercury waste	Boost knowledge amongst stakeholders who uses mercury products	Department of Environment, Department of Health, Department of Waste Management, FOFA, Department of Agriculture, Department of Education (Fetuvalu and Motufoua Secondary Schools)
	Mercury National Report	Completed and endorsed national report	CMO, BRI, SPREP, Data Expert
Ozone Depleting Substance	Update from the ODS Project	Progressive updates from the ODS project coordinator on achieved activities and future project goals	CMO and the ODS project coordinator
Chemical Monitoring and Reporting	Update all spill incidents and chemical(s) found/occurred within each year	Complete report(s) and submit it to the department's director	CMO
Laboratory	Planning and constructing the department's own laboratory for testing and outbreak purposes	Easy testing, analysing, interpretation and immediate results obtained	Department of Environment

SECTION 7

Conclusion

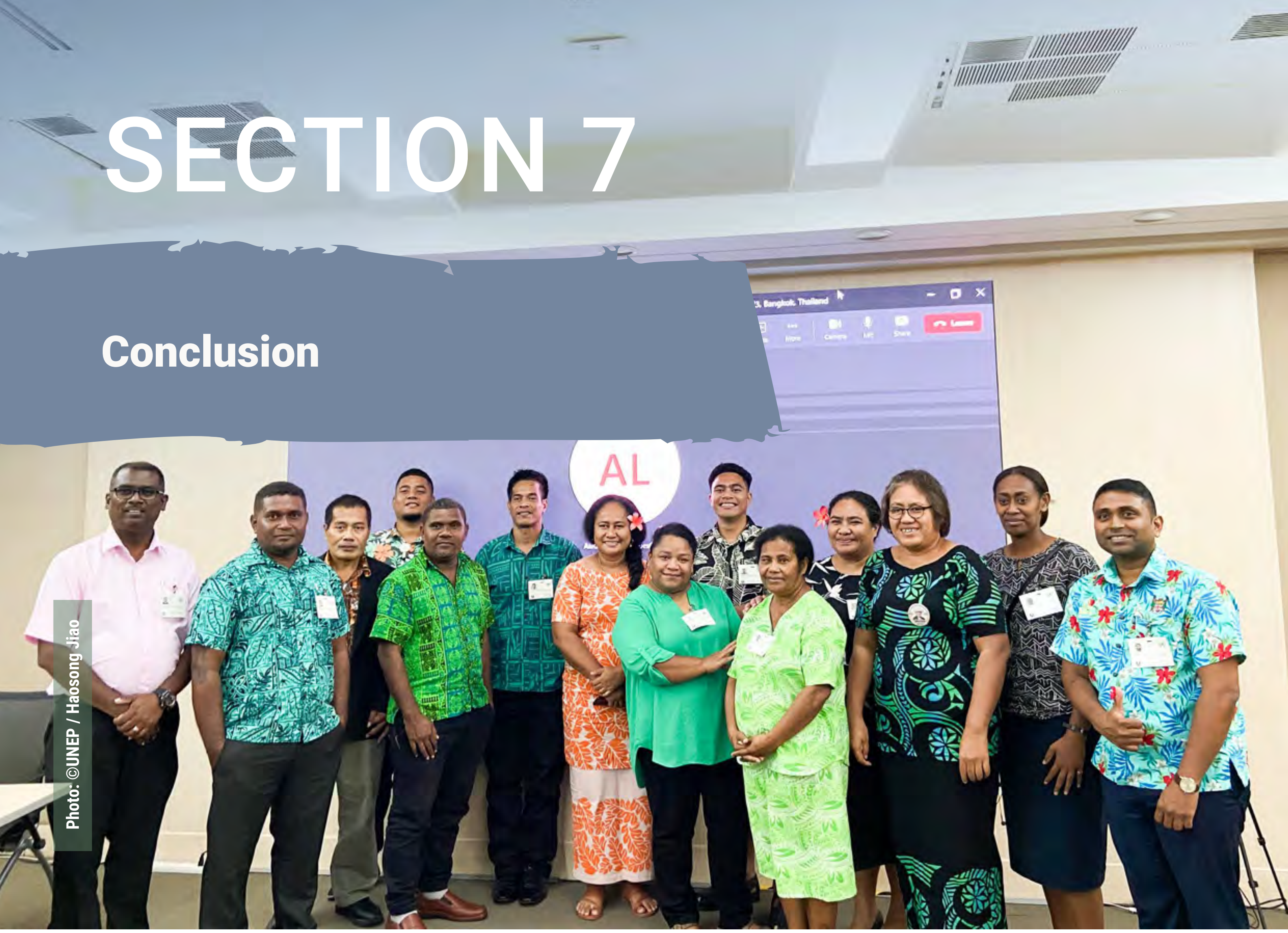


Photo: ©UNEP / Haosong Jiao

Environmental and human monitoring of POPs plays a crucial role in assessing the environmental and human exposure to these toxic chemicals, safeguarding the health of humans and the environment, and providing pivotal information to the effectiveness evaluation and implementation of the Stockholm Convention.

The UNEP/GEF POPs GMP project on POPs monitoring in Pacific region has generated a wealth of information. This report attempts to present and summarize the set-up of the regional project and includes presentation of the main actors, characterize the sampling sites and other organizational structures. The report also highlights the quantitative findings for all samples analyzed for POPs. This report is limited to the core matrices as defined in the guidance document for the global monitoring plan and includes the POPs listed in the Stockholm Convention (UNEP 2021). Results of POPs monitoring in other matrices conducted at the national level, including for example sediment and food, are included in the project national reports and publications of national and international researchers.

Through this project, POPs in core matrices including air, water and human milk were sampled in parallel in four UN regions covering 42 projects countries worldwide. In order to assess these regional data, it is recommended to compare the findings presented here with the findings from the other three (sister) regional reports addressing GRULAC, Asia, and Africa regions as well as the sectoral reports summarizing the air, water and human milk (UNEP 2023b; UNEP 2024a; UNEP 2024b; UNEP 2024c; UNEP 2024d; UNEP 2024e).

Valuable insights were generated, reflecting the extend of POPs concentrations in the three core matrices in the region and enabling comparison in the global context. Background levels of POPs have been confirmed to be widespread in the environment in the region. POPs were also detected in all the human milk samples collected. The site-specific information and the chemical measurements serve as a data reservoir for future assessments by the Parties of the Stockholm Convention but also for researchers conducting environmental or human monitoring.

Although the background information provided basic understanding of the extend of POPs levels in core matrices, significant data gaps still exist in most Pacific countries particularly for new POPs. This challenge is attributed to the limited regional and national capacities and associated analytical difficulties of complex compounds. The capacity building activities conducted under the project, including trainings in national laboratories, two rounds of interlaboratory assessments, development of protocols and training courses, have contributed to strengthened national analytical knowledge and skills. With more POPs listed under the Stockholm Convention, regional collaboration and global coordination are critical to continue strengthening regional capacities and enable sustainable data generation on environmental existence and human exposure to POPs.

Project countries have developed sustainability plans, emphasizing key areas of mutual interest. These encompass continuing POPs monitoring; capacity building to improve data quality and comparability and to facilitate data interpretation and utilization. Additionally, the plans mentioned the integration of data generation into policy-making processes, including the development and updating of national implementation plans under the Stockholm Convention. There is also a focus on understanding the key messages derived from data interpretation, gaining enhanced knowledge on health impacts and environmental risks, and establishing a sustainable modality for POPs monitoring including the continuation of financial and technical assistance, as well as fostering increased regional collaboration.

Finally, data and information gathered under the project are also shared with the Secretariat of the Stockholm Convention to support the effectiveness evaluation of the Convention and are contained in thematic reports and project publications.

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9. APPENDIX

9.1. Responsible people in the Pacific Islands Project

Table S 1: Pacific Islands: Members and the responsibilities of the national teams

Country	Responsibility	Person (name)	Affiliation	E-mail
Fiji	Coordinator	Mr. Vincent Lal	Institute of Applied Sciences The University of the South Pacific	vincent.vishant.lal@gmail.com
	Air			
	Water			
	Human milk	Mr. Johann Poinapen		johann.poinapen@usp.ac.fj
Kiribati	Coordinator	Mr. Teema Biko	Waste Management Officer Environment and Conservation Division Ministry of Environment, Lands and Agriculture	teemab@environment.gov.ki
	Air			
	Water			
	Human milk			
Marshall Islands	Coordinator	Mr. Aaron Lang	Awareness Division RMI Environmental Protection Authority	aaronlanginlur@gmail.com
	Air	Mr. Joann Komanta		jkomanta@gmail.com
	Water			
	Human milk	Ms. Jessica Zebedee		jeimack.4@gmail.com
Niue	Coordinator	Mr. Haden Talagi	Department of Environment Ministry of Natural Resources Government of Niue	Haden.Talagi@mail.gov.nu
	Air			
	Water			
	Human milk	Ms. Tesl Viliamu	Department of Health Ministry of Social Services	tesl.viliamu@mail.gov.nu
Palau	Coordinator	Ms. Metiek Kimie Ngirchechol	Water Quality and Laboratory Division Environmental Quality Protection Board	eqpb.lab@gmail.com
	Air	Ms. Zena Kulialang Rengulbai	Environmental Outreach Officer Environmental Quality Protection Board	eqpb.outreach@gmail.com; eqpb@palaunet.com
	Water			
	Human milk			
Samoa	Coordinator	Ms. Fiasosoitamalii Siaosi	Division of Environment and Conservation Ministry of Natural Resources and Environment	fiasoso.siaosi@gmail.com
	Air	Mr. Afele Faiilagi		afele.faiilagi@mnre.gov.ws
	Water			
	Human milk	Ms. Lucie Isaia		lucie.isaia@mnre.gov.ws
Solomon Islands	Coordinator	Ms. Rosemary Ruth Apa (former chief) Ms. Debra Kereseka	Environment and Conservation Division Ministry of Environment Climate Change Disaster Management and Meteorology	DKereseka@mecdm.gov.sb
	Air			
	Water			
	Human milk			
Tuvalu	Coordinator	Mrs. Setapu Resture (deceased) Mrs. Emelipelesa Sam Panapa	Coordinator Ozone Depleting Substance Project Department of Environment, Chemical Management Officer	emelysamster@gmail.com
	Air			
	Water			
	Human milk			
	National samples	Mr. Faoliu Teakau	Department of Environment, Land Degradation Officer	fteakau@gmail.com
Vanuatu	Coordinator	Ms. Roselyn Bue	Environment Officer Department of Environmental Protection and Conservation	rbue@vanuatu.gov.vu
	Air	Mr. Reedly Tari		ratari@vanuatu.gov.vu
	Water			
	Human milk	NA		

9.2. Locations of air and water sampling sites

Table S 2: Locations of air sampling sites (PAS/PUF)

Country	Physical Address	Altitude (m)	Latitude	Longitude
Fiji	Nausori meteorological office	5	-18.04672	178.55925
Kiribati	Bonriki airport area	2	1.379341	173.145018
Marshall Islands	Rearlaplap Island, Arno Atoll	15	7.087	171.907
Niue	Alofi - airport	60	-19.07694	-169.925833
Palau	Malakal Island - "industrial" area on the south west side of Koror.	13	7.33503	134.45314
Samoa	Afiamalu Area - part of the greater Apia Area	723	-13.91004	-171.790847
Solomon Islands	Honaria	65	-9.43494	159.95435
Tuvalu	Meteorological Station - Funafuti atoll	6	-8.359581	179.191183
Vanuatu	Port Vila	2	-17.72417	168.338083

Table S 3: Geographical locations for water samples under UNEP/GMP2 Pacific Islands project

Country	Site name	Type	Latitude (decimal)	Longitude (decimal)
Fiji	Waimanu River	Ocean	-18.0267	178.368659
Kiribati	Bonriki	Ocean	1.3826333	173.14612
Marshall Islands	Majuro Atoll	Ocean	7.1164222	171.185775
Niue	Alofi	Ocean	-19.05538	-169.91784
Palau	Airai	Ocean	7.3858333	134.5525
Samoa	Vaisigano River, Lelata Point	Fresh	-13.8444	-171.75767
Solomon Islands	Mataniko River, Honiara	Fresh	-9.434067	159.967114
Tuvalu	Fongafale Islet, southern end	Ocean	-8.540333	179.252222
Vanuatu	Mele Bay	Ocean	-17.70538	168.28786

9.3. Monitoring results from expert laboratories

9.3.1. Ambient Air

Table S 4: PAS/PUFs: Concentration of chlorinated POPs (ng/PUF). Numbers inside the parenthesis indicate the year and the quarter (Roman numbers I to IV) of the exposure

ISO3	Sample_ID	Drins	Chlordane	DDT	Heptachlor	HCHs	a_Endosulfan	Mirex	Toxaphene	PCB6	HCB	PeCBz	HCBD
FJI	FJI (2017-IV)	1.7	1.3	4.0	0.00	2.6	<0.39	0.12	<LOQ	1.9	2.5	0.62	0.58
FJI	FJI (2018-I)	2.4	0.89	7.3	0.87	4.1	<0.15	0.13	<LOQ	1.7	2.9	1.6	0.87
FJI	FJI (2018-II)	2.9	1.4	8.0	0.96	3.9	<0.15	0.15	0.17	3.3	2.8	1	0.7
FJI	FJI (2018-III)	1.5	1.1	3.8	2.2	3.3	<0.15	0.11	<LOQ	3.6	2.2	0.52	0.63
FJI	FJI (2019-I)	3.5	2.4	10	0.63	6.7	<0.29	0.16	<LOQ	6.6	2.5	0.71	0.69
FJI	FJI (2019-II)	3.1	1.0	6.6	0.00	4.4	<0.39	<0.11	<LOQ	3.0	2.7	0.84	1
FJI	FJI (2019-III)	1.7	1.2	4.5	0.00	3.7	<0.39	0.14	<LOQ	2.5	3.1	1.5	0.9
KIR	KIR (2017-III)	2.1	0.00	0.98	0.63	1.2	<0.3	0.16	0.46	1.3	2.5	1.2	4.1
KIR	KIR (2017-IV)	0.48	0.60	0.88	0.00	0.24	<0.39	0.15	<LOQ	0.71	2.3	0.94	6.8

Table S 4 (continued)

ISO3	Sample_ID	Drins	Chlordane	DDT	Heptachlor	HCHs	a_Endosulfan	Mirex	Toxaphene	PCB6	HCB	PeCBz	HCBD
KIR	KIR (2018-I)	0.57	0.30	0.32	0.00	0.00	<0.15	0.14	0.24	0.76	1.7	0.47	4.6
KIR	KIR (2018-II)	0.50	0.40	0.82	0.62	0.00	<0.15	0.12	<LOQ	0.87	2.7	0.74	3.6
KIR	KIR (2018-III)	0.00	0.00	1.4	0.66	0.17	<0.15	0.12	<LOQ	1.5	1.9	0.43	3.1
KIR	KIR (2018-IV)	0.00	0.51	0.68	0.10	0.00	<0.24	<0.1	<LOQ	0.68	1.2	0.46	2.9
KIR	KIR (2019-I)	0.00	0.71	1.2	0.60	0.24	<0.3	0.15	<LOQ	0.78	2.6	0.38	2
MHL	MHL (2017)	0.00	0.41	0.00	0.00	0.00	<0.41	<0.11	1.14	1.7	1.6	0.91	2.2
MHL	MHL (2019)	0.00	0.45	0.00	0.00	0.00	<0.41	<0.11	0.42	1.2	1.7	0.46	3.1
NIU	NIU (2017-4)	0.00	1.9	1.4	1.0	0.47	<0.41	<0.11	<LOQ	1.7	0.95	0.46	4.8
NIU	NIU (2017-IV)	0.00	0.59	1.3	0.43	0.31	<0.28	<0.11	0.17	1.6	1.8	<0.19	3
NIU	NIU (2018-I)	0.00	2.0	1.4	1.0	0.44	<0.41	<0.11	<LOQ	1.7	0.64	0.42	2.1
NIU	NIU (2018-II)	0.00	2.0	1.3	2.2	0.45	<0.41	<0.11	<LOQ	1.5	0.8	0.49	0.55
NIU	NIU (2018-III)	0.00	1.8	1.0	1.0	0.45	<0.41	<0.11	<LOQ	1.2	1	0.5	2.4
NIU	NIU (2018-IV)	0.00	2.0	1.3	1.0	0.46	<0.41	<0.11	<LOQ	1.6	0.81	0.45	<0.23
NIU	NIU (2019-I)	0.00	2.1	2.0	1.1	0.45	<0.41	<0.11	<LOQ	1.7	0.93	0.5	3.3
NIU	NIU (2019-II)	0.00	2.0	1.3	1.0	1.1	<0.41	<0.11	<LOQ	1.4	1.1	0.52	3.9
PLW	PLW (2017-I)	1.7	7.7	1.9	1.2	0.00	<0.26	0.2	<LOQ	4.7	3.7	1.2	<0.28
PLW	PLW (2017-II)	2.1	7.0	1.9	0.44	0.24	<0.39	0.24	<LOQ	6.0	3.4	1.4	0.87
PLW	PLW (2017-III)	2.6	6.6	1.0	1.4	0.29	<0.28	<0.11	0.19	2.5	3.8	0.89	0.97
PLW	PLW (2018-I)	2.4	5.8	1.3	0.93	0.95	<0.29	0.22	0.18	2.7	7.7	2.6	1.7
PLW	PLW (2018-II)	7.6	9.6	1.8	1.2	0.56	<0.15	0.32	0.2	5.9	4.7	1.7	2.1
PLW	PLW (2018-III)	2.0	3.6	0.44	0.78	0.00	<0.15	0.13	0.17	1.4	3.1	0.95	1.1
SLB	SLB (2017-III)	8.3	4.4	325	0.63	0.71	<0.28	0.23	<LOQ	3.0	2.1	0.36	1.4
SLB	SLB (2017-IV)	14	14	477	1.0	0.76	<0.28	0.16	<LOQ	2.8	2.3	1.1	1.7
SLB	SLB (2018-I)	10	11	667	1.3	0.46	<0.15	0.23	<LOQ	3.3	1.9	0.37	2.9
SLB	SLB (2018-II)	9.0	8.8	251	0.38	0.67	<0.15	0.32	<LOQ	2.9	1.9	0.46	0.54
SLB	SLB (2018-III)	5.5	2.7	228	0.98	0.46	1.5	0.24	<LOQ	2.7	1.8	0.32	5.8
SLB	SLB (2018-IV)	6.8	3.1	248	0.28	0.74	2.9	0.18	<LOQ	2.7	1.4	0.38	6.3
SLB	SLB (2019-I)	6.8	3.4	394	0.63	1.1	1	1.9	<LOQ	3.1	1.6	0.3	0.71
TUV	TUV (2018-I)	3.3	0.52	20	0.59	4.9	<0.15	0.17	<LOQ	3.5	4.2	0.82	4.1
TUV	TUV (2018-II)	1.8	0.57	15	0.00	1.5	<0.15	0.13	0.22	4.0	3	0.77	3.1
TUV	TUV (2018-III)	1.5	0.56	5.8	0.10	1.2	<0.22	<0.08	<LOQ	3.5	2.4	0.72	2.4
TUV	TUV (2018-IV)	1.3	0.68	9.3	0.11	1.9	<0.24	<0.1	<LOQ	2.6	1.8	0.71	3.8
VUT	VUT (2018-I)	1.2	0.43	0.72	0.00	0.24	<0.15	0.12	0.17	1.4	1.8	0.37	1.9
VUT	VUT (2018-II)	0.49	0.27	0.38	0.00	0.00	<0.15	0.09	0.17	0.99	2	0.38	1.2
VUT	VUT (2018-III)	0.00	0.48	0.35	0.10	0.55	<0.22	<0.08	<LOQ	1.19	1.4	0.37	2.2
VUT	VUT (2018-IV)	0.00	0.48	0.36	0.10	0.57	<0.22	<0.08	<LOQ	8.13	0.82	0.32	3.2
VUT	VUT (2019-I)	0.00	0.00	0.54	0.00	1.67	<0.62	<0.23	<LOQ	5.5	2.1	<0.41	3.5
VUT	VUT (2019-II)	0.58	0.00	0.47	0.00	0.22	<0.39	<0.11	<LOQ	2.2	1.6	0.27	1.1
WSM	WSM (2018-II)	0.00	0.49	1.7	0.00	0.00	<0.38	0.13	<LOQ	61	2	0.59	4.4
WSM	WSM (2018-III)	0.00	0.46	1.0	0.53	0.00	<0.38	0.12	<LOQ	13	2.5	0.57	3.5

Table S 5: PAS/PUFs: Concentration of dl-POPs (pg TEQ/xPUF). Numbers inside the parenthesis indicate the year and the quarter (Roman numbers I to IV) of the exposure

ISO-3	Sample ID	Unit	TEQ_DF	TEQ_PCB
FJI	FJI (2017-IV)	pg/1 PUF	1.0	1.2
FJI	FJI (2018-I+II+III)	pg/3 PUF	40.9	13.0
FJI	FJI (2019-I+II)	pg/2 PUF	21.5	7.1
KIR	KIR (2017-III+IV)	pg/2 PUF	0.5	0.6
KIR	KIR (2018-I+II+III+IV)	pg/4 PUF	3.5	0.0
MHL	MHL (-)	pg/2 PUF	0.0	0.0

Table S 5 (continued)

NIU	NIU (2017-IV)	pg/1 PUF	0.0	0.0
NIU	NIU (2018-I+II+III+IV)	pg/4 PUF	0.3	0.0
NIU	NIU (2019-I+II)	pg/2 PUF	0.3	0.0
PLW	PLW (2017-I)	pg/1 PUF	0.0	0.7
PLW	PLW (2017-II)	pg/1 PUF	1.2	0.8
PLW	PLW (2017-III+IV)	pg/2 PUF	15.4	1.0
PLW	PLW (2018-II+III)	pg/2 PUF	3.0	2.3
SLB	SLB (2017-III+IV)	pg/2 PUF	54.1	4.8
SLB	SLB (2018-I+II+III+IV)	pg/4 PUF	43.2	8.1
TUV	TUV (2017-I+II+III+IV)	pg/4 PUF	0.8	1.9
TUV	TUV (2018-I+II+III+IV)	pg/4 PUF	1.1	1.5
VUT	VUT (2018-I+II+III+IV)	pg/4 PUF	8.2	0.1
WSM	WSM (2018-undef)	pg/6 PUF	0.2	14.6
WSM	WSM (2018b-undef)	pg/6 PUF	3.6	5.4

Table S 6: PAS/PUFs: Concentration of brominated flame retardants (ng/PUF). Numbers inside the parenthesis indicate the year and the quarter (Roman numbers I to IV) of the exposure

ISO3	Sample_ID	$PBDE_8$	HBCDs	PBB153
FJI	FJI (2018-I)	6.3	0.12	<0.08
FJI	FJI (2018-II)	15	0.20	<0.08
FJI	FJI (2018-III)	7.4	0.13	<0.08
FJI	FJI (2019-I)	4.8	4.5	<0.08
FJI	FJI (2019-II)	11	0.06	0.1
FJI	FJI (2019-III)	8.6	0.04	<0.08
KIR	KIR (2017-III)	0.83	0.00	<0.08
KIR	KIR (2017-IV)	0.86	0.59	<0.08
KIR	KIR (2018-I)	1.1	0.06	<0.08
KIR	KIR (2018-II)	0.41	0.77	<0.08
KIR	KIR (2018-III)	1.3	2.7	<0.08
KIR	KIR (2018-IV)	2.5	0.22	<0.08
KIR	KIR (2019-I)	3.4	1.1	<0.08
MHL	MHL (2017)	6.1	0.08	<0.08
MHL	MHL (2019)	3.2	0.09	<0.08
NIU	NIU (2017-4)	0.89	0.00	<0.08
NIU	NIU (2017-IV)	0.00	0.00	<0.08
NIU	NIU (2018-I)	0.93	0.00	<0.08
NIU	NIU (2018-II)	0.85	0.00	<0.08
NIU	NIU (2018-III)	0.71	0.00	<0.08
NIU	NIU (2018-IV)	0.42	0.00	<0.08
NIU	NIU (2019-I)	0.64	0.10	<0.08
NIU	NIU (2019-II)	0.99	0.00	<0.08
PLW	PLW (2017-I)	3.1	0.14	<0.08
PLW	PLW (2017-II)	4.1	0.66	<0.08
PLW	PLW (2017-III)	4.6	0.04	<0.08
PLW	PLW (2018-I)	4.4	0.77	<0.08
PLW	PLW (2018-II)	7.7	0.31	<0.08
PLW	PLW (2018-III)	2.6	0.06	<0.08
SLB	SLB (2017-III)	1.1	0.00	<0.08
SLB	SLB (2017-IV)	0.90	0.00	<0.08
SLB	SLB (2018-I)	0.91	0.00	<0.08
SLB	SLB (2018-II)	2.3	0.00	<0.08

Table S 6 (continued)

ISO3	Sample_ID	$PBDE_8$	HBCDs	PBB153
FJI	FJI (2018-I)	6.3	0.12	<0.08
SLB	SLB (2018-III)	1.9	0.55	<0.08
SLB	SLB (2018-IV)	1.1	0.12	<0.08
SLB	SLB (2019-I)	1.2	0.06	<0.08
TUV	TUV (2018-I)	0.42	0.07	<0.08
TUV	TUV (2018-II)	0.23	0.00	<0.08
TUV	TUV (2018-III)	0.00	0.07	<0.08
TUV	TUV (2018-IV)	0.22	1.1	<0.08
VUT	VUT (2018-I)	0.00	3.6	<0.08
VUT	VUT (2018-II)	0.33	0.49	<0.08
VUT	VUT (2018-III)	0.00	3.7	<0.08
VUT	VUT (2018-IV)	0.38	1.3	<0.08
VUT	VUT (2019-I)	0.66	49	0.23
VUT	VUT (2019-II)	0.25	0.15	<0.08
WSM	WSM (2018-II)	1.6	0.00	<0.08
WSM	WSM (2018-III)	1.4	0.00	0.09

Table S 7: PAS/PUFs: Concentration of PFAS (pg/x PUF). Numbers inside the parenthesis indicate the year and the quarter (Roman numbers I to IV) of the exposure Values <LOQ are shown in red color; NR indicates that quantification was not possible due to interferences

ISO3	Sample ID	Unit	∑PFOS	PFOA	PFHxS	FOSA
FJI	FJI (2017-IV)	pg/1 PUF	177	94	49	NR
FJI	FJI (2018-I)	pg/1 PUF	340	144	<12	<25
FJI	FJI (2018-I+II+III)	pg/3 PUF	1,273	644	197	NR
FJI	FJI (2018-II)	pg/1 PUF	433	139	<12	NR
FJI	FJI (2018-III)	pg/1 PUF	220	123	<12	NR
FJI	FJI (2019-I)	pg/1 PUF	NR	NR	NR	NR
FJI	FJI (2019-I+II+IV)	pg/3 PUF	NR	NR	NR	NR
FJI	FJI (2019-II)	pg/1 PUF	NR	NR	NR	NR
FJI	FJI (2019-IV)	pg/1 PUF	NR	NR	NR	NR
KIR	KIR (2017-III)	pg/1 PUF	476	307	79	NR
KIR	KIR (2017-III+IV)	pg/2 PUF	1,124	592	121	232
KIR	KIR (2017-IV)	pg/1 PUF	525	417	40	NR
KIR	KIR (2018-I)	pg/1 PUF	488	376	92	NR
KIR	KIR (2018-I+II+III+IV)	pg/4 PUF	1,844	964	282	NR
KIR	KIR (2018-II)	pg/1 PUF	398	NR	60	<25
KIR	KIR (2018-III)	pg/1 PUF	507	211	60	<25
KIR	KIR (2018-IV)	pg/1 PUF	474	265	91	<25
KIR	KIR (2019-I)	pg/1 PUF	NR	NR	NR	NR
MHL	MHL (2017-UNK)	pg/1 PUF	178	237	47	<25
NIU	NIU (2017-IVa)	pg/1 PUF	458	217	79	281
NIU	NIU (2017-IVb)	pg/1 PUF	602	NR	163	669
NIU	NIU (2018-I)	pg/1 PUF	288	<13	95	264
NIU	NIU (2018-I+II+III+IV)	pg/4 PUF	NR	NR	NR	<25
NIU	NIU (2018-II)	pg/1 PUF	NR	NR	123	<25
NIU	NIU (2018-III)	pg/1 PUF	NR	NR	NR	<25
NIU	NIU (2018-IV)	pg/1 PUF	NR	NR	206	<25
NIU	NIU (2019-I)	pg/1 PUF	NR	NR	NR	NR
NIU	NIU (2019-I+II)	pg/2 PUF	NR	NR	NR	<25
NIU	NIU (2019-II)	pg/1 PUF	NR	187	106	<25

Table S 7 (continued)

ISO3	Sample ID	Unit	∑PFOS	PFOA	PFHxS	FOSA
PLW	PLW (2017-I)	pg/1 PUF	321	268	<12	NR
PLW	PLW (2017-I+II+III+IV)	pg/4 PUF	973	703	82	538
PLW	PLW (2017-II)	pg/1 PUF	318	151	39	NR
PLW	PLW (2017-III)	pg/1 PUF	156	133	<12	NR
PLW	PLW (2017-IV)	pg/1 PUF	162	212	<12	NR
PLW	PLW (2018-II)	pg/1 PUF	299	279	<12	NR
PLW	PLW (2018-II+III)	pg/2 PUF	468	416	<12	NR
PLW	PLW (2018-III)	pg/1 PUF	65	126	<12	66
SLB	SLB (2017-III)	pg/1 PUF	120	154	<12	NR
SLB	SLB (2017-III+IV)	pg/2 PUF	240	206	<12	88
SLB	SLB (2017-IV)	pg/1 PUF	158	94	<12	<25
SLB	SLB (2018-I)	pg/1 PUF	97	NR	<12	<25
SLB	SLB (2018-I+II+III+IV)	pg/4 PUF	359	446	<12	<25
SLB	SLB (2018-II)	pg/1 PUF	85	154	23	<25
SLB	SLB (2018-III)	pg/1 PUF	93	101	25	NR
SLB	SLB (2018-IV)	pg/1 PUF	84	113	35	NR
SLB	SLB (2019-I)	pg/1 PUF	NR	NR	NR	NR
TUV	TUV (2018-I)	pg/1 PUF	556	186	43	<25
TUV	TUV (2018-I+II+III+IV)	pg/4 PUF	2,859	897	226	<25
TUV	TUV (2018-II)	pg/1 PUF	827	232	60	<25
TUV	TUV (2019-I)	pg/1 PUF	NR	NR	NR	NR
VUT	VUT (2018-I)	pg/1 PUF	<12	99	<12	NR
VUT	VUT (2018-I+II+III+I)	pg/4 PUF	<12	419	<12	<25
VUT	VUT (2018-II)	pg/1 PUF	<12	72	<12	NR
VUT	VUT (2018-III)	pg/1 PUF	<12	NR	<12	<25
VUT	VUT (2019-I)	pg/1 PUF	<12	107	<12	NR

9.3.2. Water

Table S 8: Concentration of PFAS in water: ΣPFOS, PFOA and PFHxS in (ng L^{-1}) for Pacific Islands samples collected under the UNEP project in the years from 2017 to 2019. Numbers inside the parenthesis indicate the year and the quarter (1-4) of the sampling

Sample_ID	Year	PFOS	PFOA	PFHxS
FJI (2017-3)	2017	<LOQ	<LOQ	<LOQ
FJI (2017-4)	2017	0.03	<LOQ	<LOQ
KIR (2017-3)	2017	1.93	0.17	1.62
KIR (2017-4)	2017	0.61	0.09	0.36
NIU (2017-3)	2017	0.17	<LOQ	0.09
PLW (2017-1)	2017	0.23	<LOQ	<LOQ
PLW (2017-2)	2017	0.08	<LOQ	<LOQ
PLW (2017-3)	2017	<LOQ	<LOQ	<LOQ
PLW (2017-4)	2017	<LOQ	<LOQ	<LOQ
WSM (2017-4)	2017	0.18	<LOQ	<LOQ
SLB (2017-3)	2017	0.06	0.06	0.05
SLB (2017-4)	2017	0.18	0.09	0.08
TUV (2017-4)	2017	0.05	<LOQ	<LOQ
VUT (2017-3)	2017	3.98	1.51	3.51
FJI (2018-3)	2018	<LOQ	<LOQ	<LOQ
FJI (2018-4)	2018	<LOQ	<LOQ	<LOQ

Table S 8 (continued)

Sample_ID	Year	PFOS	PFOA	PFHxS
FJI (2019-1)	2018	0.05	0.05	<LOQ
KIR (2018-1)	2018	1.68	0.12	0.20
KIR (2018-2)	2018	1.03	0.13	0.26
KIR (2018-3)	2018	0.42	0.11	0.15
KIR (2018-4)	2018	0.08	0.07	0.04
KIR (2019-1)	2018	4.70	0.25	1.79
MHL (2018-1)	2018	0.03	<LOQ	<LOQ
MHL (2018-2)	2018	<LOQ	<LOQ	<LOQ
MHL (2018-3)	2018	<LOQ	<LOQ	<LOQ
MHL (2018-4)	2018	<LOQ	<LOQ	<LOQ
PLW (2018-1)	2018	<LOQ	<LOQ	0.03
PLW (2018-4)	2018	0.04	0.05	<LOQ
WSM (2018-1)	2018	0.05	<LOQ	<LOQ
WSM (2018-2)	2018	<LOQ	<LOQ	<LOQ
WSM (2018-3)	2018	0.04	0.05	<LOQ
WSM (2018-4)	2018	<LOQ	<LOQ	<LOQ
WSM (2019-1)	2018	0.06	0.06	<LOQ
SLB (2018-1)	2018	0.20	0.06	0.11
SLB (2018-2)	2018	1.12	0.13	0.50
SLB (2018-3)	2018	0.28	0.12	0.15
SLB (2018-4)	2018	0.22	0.14	0.06
TUV (2018-1)	2018	<LOQ	0.07	<LOQ
TUV (2018-2)	2018	0.03	<LOQ	<LOQ
TUV (2018-3)	2018	<LOQ	<LOQ	0.03
VUT (2018-1)	2018	6.23	0.72	2.69
VUT (2018-2)	2018	4.77	0.84	3.13
VUT (2018-3)	2018	5.58	0.64	2.68
VUT (2018-4)	2018	4.48	0.64	2.77
VUT (2019-1)	2019	3.94	0.54	2.46
VUT (2019-2)	2019	5.20	0.68	2.64

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