Capacity Building Activities and the Monitoring of POPs Concentration in Air and Trends in Fiji During 2008 – 2019

Lal VV*

The Institute of Applied Sciences, School of Agriculture, Geography, Environment, Ocean and Natural Sciences, the University of the South Pacific, Suva, Fiji, vincent.lal@usp.ac.fj

1 Introduction

Persistent organic pollutants (POPs) comprise of a large group of chemical compounds that are also globally distributed in air (Bogdal et al., 2013). Many of the POPs are identified for analysis and inclusion into the list of compounds to be monitored within the global monitoring plan (GMP) established under the Stockholm Convention (UNEP, 2019). Fiji as a Party to the to the Stockholm Convention on POPs has updated its national implementation plan (NIP) that outlines the actions to be undertake to meet its commitments under the Convention. These plans are publicly accessible at the Convention's website (Stockholm Convention, 2019). Fiji received support under provisions in Article 11 on research, development, monitoring, and Article 12 on technical assistance to developing countries. During 2008 – 2019 the GMP activities in Fiji executed by UNEP provided opportunities to build capacity in areas of field-based sampling, set-up analytical laboratory capacity to test basic POPs and measure and assess the presence of POPs in country. Ambient air as a core matrix were collected and analyzed for a limited number of POPs.

The GMP activities executed by UNEP in Fiji commenced in 2008. Ambient air was selected as a core matrix to study distribution of POPs in the environment in country. From 2008 – 2011, UNEP coordinated air sampling using passive air samplers polyurethane foam disks (PAS/PUF) in Fiji in collaboration with the Institute of Applied Sciences (IAS) based at the University of the South Pacific (USP). Samples were analysed at the UNEP "expert laboratories" at the Man-Technology-Environment (MTM) Research Centre in Örebro (Sweden) and the Institute for Environmental Studies (IVM) in Amsterdam (the Netherlands). The UNEP-coordinated GMP activities in the Fiji also included workshops, training and interlaboratory tests to assist Fiji in providing accurate data to the Stockholm Convention. Overall, the UNEP coordinated activities from 2008 - 2011 in Fiji lay the basis for future monitoring of POPs levels and trends in country. Under the Phase 2 of GMP (GMP2), the UNEP Chemicals and Waste Branch continued its support to the GMP with a second wave of activities in Fiji from 2016 to 2019. Under this initiative, 14 new POPs were added to the original list of 12 POPs for analysis in human milk, ambient air and for the first time in surface water. The newly added POPs included; chlordecone, endosulfan, hexachlorobutadiene, hexachlorocyclohexanes, hexabromodiphenyl ether, heptabromodiphenyl ether, tetrabromodiphenyl ether, pentabromodiphenyl ether, octabromodiphenyl ether, hexabromobiphenyl, pentachlorobenzene, hexabromocyclododecane and perfluorooctanesulfonic acid, its salts and perfluorooctane sulfonyl fluoride (Stockholm Convention, 2019). This paper aims to give an overview on the capacity building activities and monitoring of POPs in ambient air in Fiji during 2008 to 2019. It summarizes the results of national sampling, training, workshops as well as the development of the POPs reference laboratory within the UNEP-coordinated GMP project, it identifies concentrations and trends of POPs in Fiji.

2 Materials and Methods

During GPM technicians from the USP IAS received training on PAS/PUF and analysis of basic POPs using GC-μECD. The IAS technicians during GMP project trained local government officials in the Health, Environment and Metrological Departments on setting up PAS/PUF and sending samples to the UNEP POPs reference laboratories in Europe for the analyses of OCPs, PCBs, PFAS, dioxins and dioxins-like chemicals. A project inception workshop at USP IAS was organized to identify timelines for sampling activities and provide an introduction to the POPs testing laboratory in Fiji based at IAS. Ambient air samples were collected using polyurethane foam disks (PUFs) according to the UNEP standard operating protocols (UNEP, 2012; UNEP, 2017). Briefly, all PUF air samples collected were stored wrapped in two layers of aluminum foil and placed in zip-lock bags with sample information. Samples were kept cool while being transported to IAS and UNEP POPs laboratories. The PAS/PUF were deployed at sites designated as "national sites" for long-term monitoring of POPs in Fiji. Duplicate air samples were analysed at the POPs laboratory in Fiji at the IAS for basic POPs (i.e. OCPs and indicator PCBs) during 2008 - 2011. Additional PAS/PUFs were deployed in other sites across Fiji to monitor the concentration of POPs in different land-use in Fiji (Table 1). These PUFs were analysed at the Queensland Alliance for Environmental Health Sciences (QAEHS) at the University of Queensland (UQ) in Brisbane, Australia.

Table 1: Collection of ambient air samples using PAS/PUF from different land-use areas and national sites in Fiji

Matrix	Sample	Location	Description
Air	F1_01	Nausori metro office	Collected within vicinity of airport
	F2_01	Nadi metro office	Collected within vicinity of airport
	F3_01	Labasa village	From sugarcane growing region
	F4_01	Savusavu village	From mountain area remote region
	F5_01	Lautoka industrial	Within vicinity of industrial zone

3 Results and Discussion

In 2007, as part of "train the trainer" initiative, IAS technicians received training in Suva (Fiji) on the use of PAS and handling of PUFs by visiting experts from UNEP (Prof Heidi Fieldlore) and MTM (Prof Bert van Bavel and Prof Gunilla Lindstrom). During the same visit, existing capacity to analyse OCPs and PCBs at IAS using GC-ECD was improved by a implementing a robust clean-up technique using alumina and silica-based columns to obtain clean extracts. Additional steps included introduction of internal standards, using isooctane as a "keeper" and reducing the final volume from 5ml to approximately 100 µL using glass inserts. The POPs experts were able to demonstrate to IAS technicians how these changes improved chromatography using existing GC-ECD. In the same year, two IAS technicians attended a laboratory-based training on analysis of POPs in PUFs and sediments at IVM at the VU University of Amsterdam in the Netherlands. The training at IVM focused on the use the internal standard technique and GC-µECD for analysis of OCPs and PCBs.

In 2008, technicians from IAS trained local government officials in Fiji on sampling protocols that included installation of PAS, removal of PUFs as well as storage conditions and instructions on packaging requirements to send air samples by courier to UNEP POPs "expert laboratories". The officials trained for deployment of samplers were from the Ministry of Environment (MoE) and the Department of Metrology in each country. Training included managers and senior officials as well as technicians from government departments that would represent in-country sampling team for air sampling. The sites for national sampling location of PAS was established by IAS technicians in consultation with senior officials and with reference to standard operating protocols (UNEP, 2012). The sampling sites were identified for long-term monitoring of POPs in Fiji. The national sampling sites were located within the vicinity of metrological stations in Nadi (F2_01) and Nausori (F1_01). In the same year, the GMP POPs project inception workshop was held at USP IAS which provided stakeholders from Fiji and other Pacific Islands Countries the opportunity to learn more about POPs, the GMP project and visit the POPs testing laboratory in Fiji.

An analysis of four major POPs found in ambient air from the national site PAS site (F1_01) on the Island of Vitilevu in Fiji from the period 2010 to 2019 is shown in Fig. 1. For ∑DDTs, the highest concentration in ambient air was found in 2010 (334 ng/PUF) and lowest concentrations were detected in 2017 (4 ng/PUF). The mean concentration of ∑DDTs analysed in ambient air between 2017 - 2019 has been found in a range of 4 to 10 ng/PUF (SD=2; median= 7). Notably, p,p'-DDT is found as the major contributor to ∑DDTs from 2010 to 2019. The p,p'-DDT concentrations contributed 30-54% towards ∑DDTs.

The same national site was used to assess trends in terms of concentration of PCDD/PCDFs and dl-PCBs in ambient air samples using PAS at F1_01 in Fiji from 2010 to 2019. The levels of ∑PCDD/PCDF were found in a range of 33 to 164 pg/PUF (SD=48; median=117). Concentrations of ∑dl-PCBs were detected in comparatively higher concentrations in a range of 898 to 2286 pg/PUF (SD=537; median=1161). The PCB 118 was found in relatively high concentrations in all samples and contributed 48-57% to ∑dl-PCBs.

Generally, the concentration of POPs in air indicate decreasing trend for major POPs such as DDTs, this is a positive reflection on the effectiveness evaluation of the Stockholm Convention through the GMP. Inclusion of more sampling sites across Fiji for monitoring of POPs in air using PAS/PUF in will provide a better understanding on dispersion of POPs in island countries and can be useful to inform policy such as Fiji's national implementation plan on POPs.

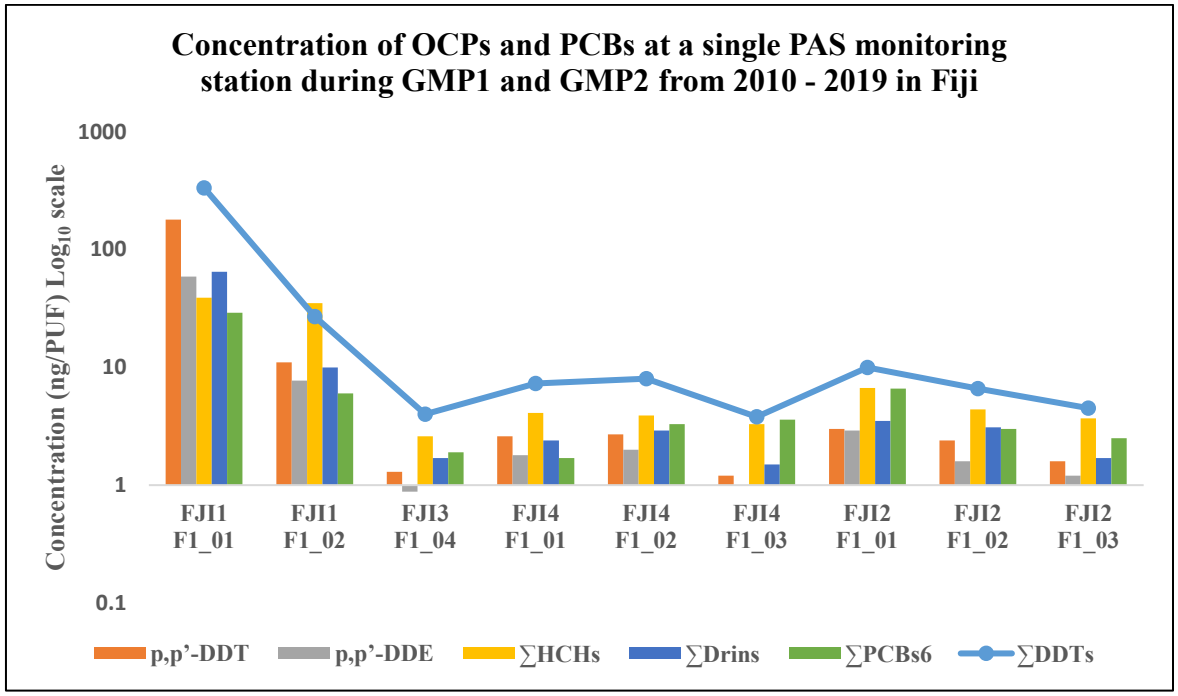

Figure 1: OCP and PCB concentrations in PUFs from Fiji (ng/PUF); F1 – Site 1 (Nausori, Fiji), FJI1 F1_01 and FJI F1_02 represent sampling from April – Sept, 2010; FJI 3 F1_04 represents sampling from Oct – Dec, 2017; FJI4 F1_01, FJI4 F1_02 and FJI4 F1_03 represents sampling from Jan – Sept, 2018 and FJI 2 F1_01, FJI2 F1_02 and FJI2 F1_03 represent sampling period Jan – Sept, 2019.

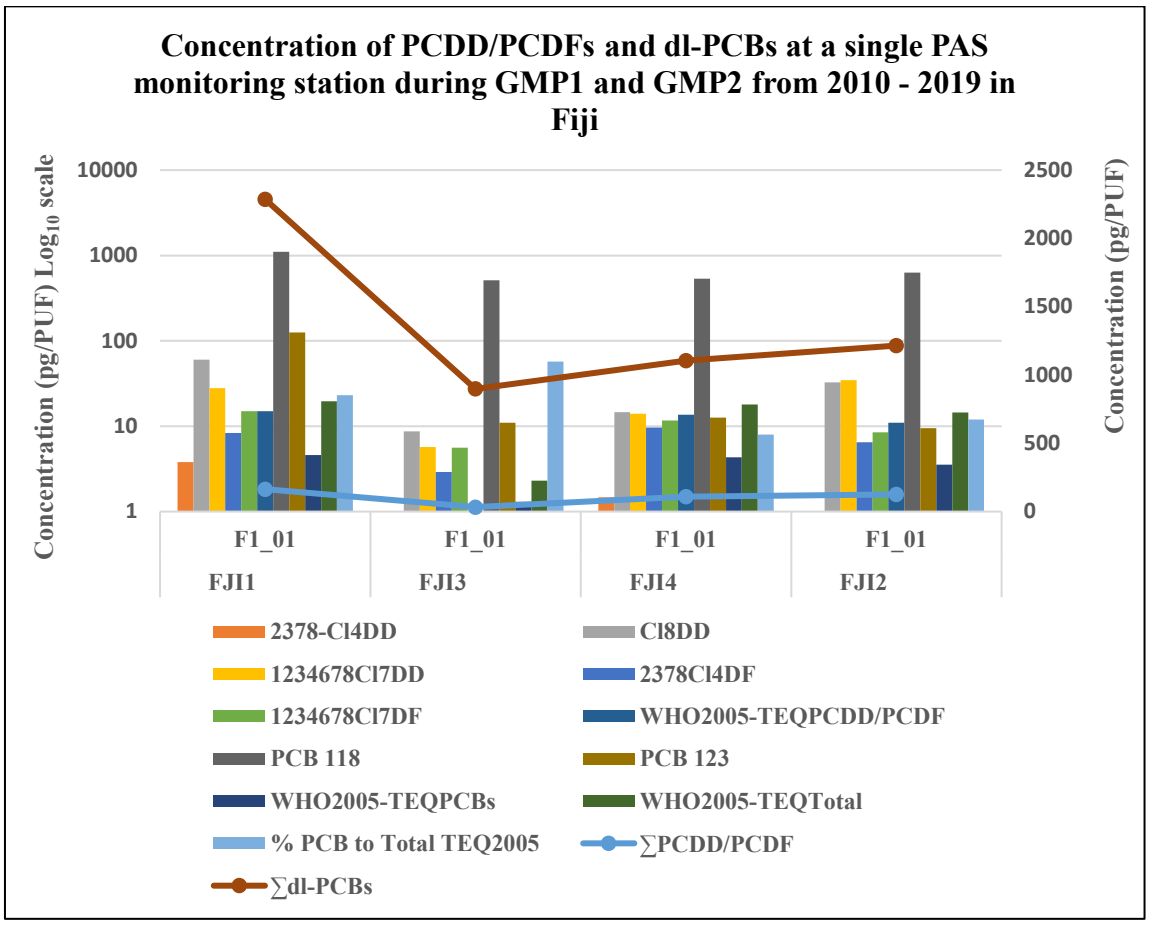

Figure 2: PCDD/PCDF and dl-PCB concentrations in PUFs from Fiji (pg/PUF); F1 – Site 1 (Nausori, Fiji), FJI1 F1_01 represents sampling from April – Sept, 2010; FJI 3 F1_01 represents sampling from Oct – Dec, 2017; FJI4 F1_01, represents sampling from Jan – Sept, 2018 and FJI 2 F1_01 represent sampling period Jan – June, 2019.

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5 References
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