EXPOSURE TO PERSISTENT ORGANIC POLLUTANTS: TRENDS AND LEVELS IN HUMAN MILK FROM FIJI

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Introduction

The Stockholm Convention is a global treaty on elimination of persistent organic pollutants (POPs) and came into force in May 2004. Fiji was the second country after Canada to ratify the Stockholm Convention, thereby agreeing to formulate a National Implementation Plan (NIP) to monitor and control the release of POPs in the country. POPs are hazardous chemicals that are persistent, bioaccumulate in food chains and have the potential to impact at all levels of the trophic system. Fiji is an archipelago of more than 300 islands which lies between 15^o- 22.5^oS latitude and 174^oE - 177^oW longitude and is spread over a total area of 709,700km[1], of which 97% is ocean[2]. The current population of Fiji is estimated at about 824,700[2]. The larger islands in Fiji are quite mountainous, but also contain significant flat plains; it is on these flat plains that most agricultural and commercial activities are located and where pollution problems are most likely to occur[1]. Fiji, like many developing countries in the world, has limited or no monitoring data on POPs concentration in the environment and on the exposure of wildlife and humans to these chemicals. Only a few studies on pesticide levels have been carried out in the South Pacific region, including Fiji and relatively little is known on the occurrence of organochlorine chemicals. Furthermore, data on dioxin and furan levels in the abiotic environment of Fiji is limited to a study on soil and sediments[3]. Soil and sediments are considered important sinks for dioxin-like chemicals in the environment and their analysis has been used to evaluate potential emission sources of these chemicals[4]. Moreover, there is very limited data on dioxin (PCDD), furan (PCDF) and dioxin-like PCB (dl-PCBs) concentrations and exposure in human populations in Fiji. First data on POPs concentration in human milk in Fijian population came from a World Health Organisation (WHO) study[5]. In this paper, we report concentrations and temporal trends for organochlorine pesticides, polychlorinated biphenyls, dioxins, furans and dl-PCBs in human breast milk samples from Fiji.

Materials and methods

Composite human breast milk samples from Fiji were shipped to the WHO reference laboratory (State Institute for Chemical and Veterinary Analysis of Food) in Germany for the analysis of PCDD/PCDF, dl-PCBs and basic POPs. Human breast milk samples from Kadavu Island (rural Fiji) was also tested for basic POPs such as organochlorine pesticides (OCPs) and polychlorinated biphenyl (PCBs) at the Institute of Applied Sciences (IAS) laboratory in Fiji. In brief, approximately 5 – 6 g of composite human breast milk samples from new mothers in Kadavu were soxhlet extracted for a minimum of 16 hours using 175 mL of hexane; acetone (3:1 v/v). For each gram of wet sample, 3 g of anhydrous sodium sulphate was added to dry the sample. Clean-up for samples was done on an alumina column, while fractionation was done over silica column. Analysis for organochlorine pesticides and PCBs was carried out at the Institute of Applied Sciences (IAS), an ISO17025 accredited laboratory using methods adopted from the Institute for Environmental Studies (IVM) analytical methods for UNEP Chemicals POPs Training Project (i.e Internal standard technique and quantification using a high resolution gas chromatograph with a micro-ECD)[6]. Analytes of interest targeted in this study included the organochlorine pesticides (including DDTs, HCHs and Drins), indicator PCBs, dioxins (PCDD), furans (PCDF) and dioxin-like PCBs (dl-PCBs). Recoveries of the internal standard (PCB 103 and PCB 198) were calculated for all samples and were used as a measure of quality control and quality assurance (QC/QA) to assess the methodology for basic POPs. A laboratory blank was included as well.

Results and discussion

The recoveries of the internal standards were between 72 – 104 %. A number of contaminants including DDTs, HCHs, and indicator PCBs (28, 52, 101, 118, 153, 138, 180) were detected. The concentrations of ΣDDTs (total of o,p'DDT, p,p'DDT, o,p'DDD, p,p'DDD, o,p'DDE, p,p'DDE) found in the human milk samples from Kadavu in Fiji Islands are summarized in Table 1. The concentration range for ΣDDTs detected in the human milk samples was 3.4 to 4.6 ng g^{-1} (SD = 0.5; median = 4.2) wet weight. Furthermore, p,p'DDE is found as the dominant contributor towards ΣDDTs in human milk samples from Kadavu. The p,p'DDE concentrations contributed 69 – 87 % towards ΣDDTs present in the human milk sample. It is also noteworthy that the most recent concentration data on ΣDDTs in human breast milk samples from Fiji population indicates a decline since the WHO study in 2004 (Figure 1). This is consistent with other studies that highlight that DDT concentrations in human milk have declined in most areas of the world, consistent with restrictions on its use[7].

The concentrations for ΣHCHs (total for α-HCH, β-HCH, γ-HCH, δ-HCH) found in the human milk from Kadavu are summarized in table 1. The concentration range for ΣHCHs detected in the milk samples was 0.6 to 0.9 ng g^{-1} (SD = 0.1; median = 0.6) wet weight. The results indicate that β-HCH concentrations contribute 82 – 83 % towards ΣHCHs present in the human milk sample. The concentrations for ΣDrins (total of Aldrin, Dieldrin, Telodrin) found in the human milk samples are summarized in table 1. The concentration range for ΣDrins detected in the milk samples was 2.3 to 4.3 ng g^{-1} (SD = 1.1; median = 2.5) wet weight. The results indicate that dieldrin concentrations contribute 96 – 97 % towards ΣDrins.

The concentrations for $\Sigma PCBs_7$ found in the human milk samples from Kadavu (rural Fiji) are summarized in table 1. The concentration range for $\Sigma PCBs_7$ detected in the milk samples was 2.5 to 4.5 ng g^{-1} (SD = 0.9; median = 2.5) wet weight. The results indicate that PCB 52 concentrations contribute 82 – 91 % towards $\Sigma PCBs_7$. The concentrations for $\Sigma PCBs_7$ found in the human milk samples from Fiji are summarized in table 2. It is significant that the most recent concentration data on $\Sigma PCBs_7$ in human breast milk samples from Fiji population have declined since the WHO study in 2004 (Table 2). Similarly, the WHO PCB-TEQ levels in human breast milk samples from Fiji have also declined slightly in comparison to the 2004 WHO PCB-TEQ data on human breast milk from Fiji (Table 3). However, the WHO PCDD/PCDF-TEQ levels in human breast milk samples from Kadavu in Fiji have increased since the WHO PCDD/PCDF-TEQ study in 2004 (Figure 2). This may be a contribution from localised sources that may include burning related activities. Kadavu Island is fairly isolated from urban centres of Fiji and people depend on more crude sources of energy such as wood fuel for everyday household energy needs.

Overall it can be seen that ΣDDTs are still the dominant POP chemical found in human breast milk samples from Fiji with highest contribution by p,p' DDE towards ΣDDTs. Also it significant that concentrations of most legendary POP chemicals including ΣDDTs and $\Sigma PCBs_7$ have declined in human breast milk samples from Fiji, however, concentrations of PCDD/PCDF in human breast milk samples from Fiji have increased over time, particularly in remote Fiji which is less developed. Additional national studies on exposure of local populations to the newly added POPs to the Stockholm Convention during the 4th meeting of the Conference of the Parties (COP4) in 2009 will provide important information for guidance on risk management actions and a baseline for future monitoring of concentrations and trends.

Table 1: Summary of concentrations (ng g^{-1} wet weight) for ΣDDTs, ΣHCHs, $\Sigma PCBs_7$ detected in composite human milk samples from Kadavu, Fiji Islands

Sum basic POPs	CompM1	CompM2	CompM3	Blank
ΣDDTs	4.2	3.4	4.6	0.2
ΣHCHs	0.6	0.9	0.6	0.01
ΣDrins	2.3	4.3	2.5	0.1
$\Sigma PCBs_7$	2.5	4.0	2.5	0.1

Table 2. ΣDDTs and $\Sigma PCBs_7$ levels (ng g^{-1} fat) in human milk samples from Fiji

	Fiji WHO 2004	Fiji UNEP 2011
ΣDDTs (ng g^{-1}fat)	688.9	586.3
$\Sigma PCBs_7$ (ng g^{-1}fat)	11.5	11.1

Table 3. WHO PCDD/PCDF/dl-PCB TEQ levels (pg g^{-1} fat) in human milk from Kadavu

	Kadavu WHO 2004	Kadavu UNEP 2011
WHO PCDD/PCDF-TEQ (pg/g) fat	4.1	4. 6
WHO PCB-TEQ(pg/g) fat	8.6	8.1

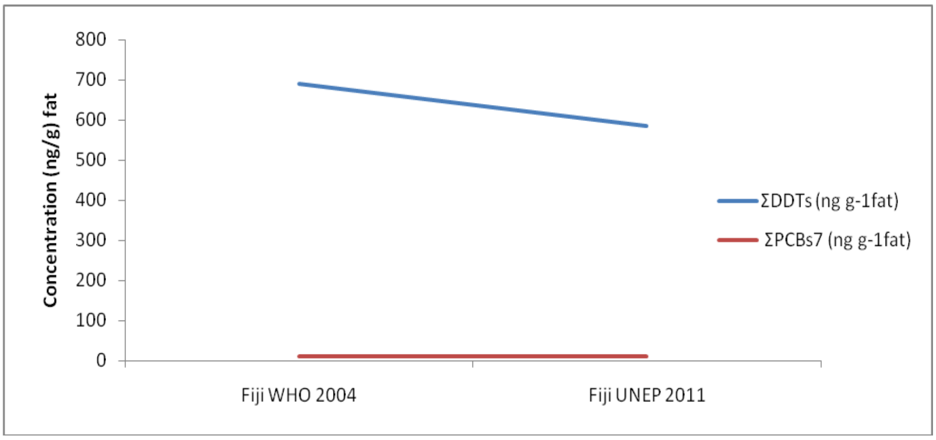

Figure 1. Trends in ΣDDTs and ΣPCBs$_7$ (ng g^{-1}) in fat of human milk samples from Fiji

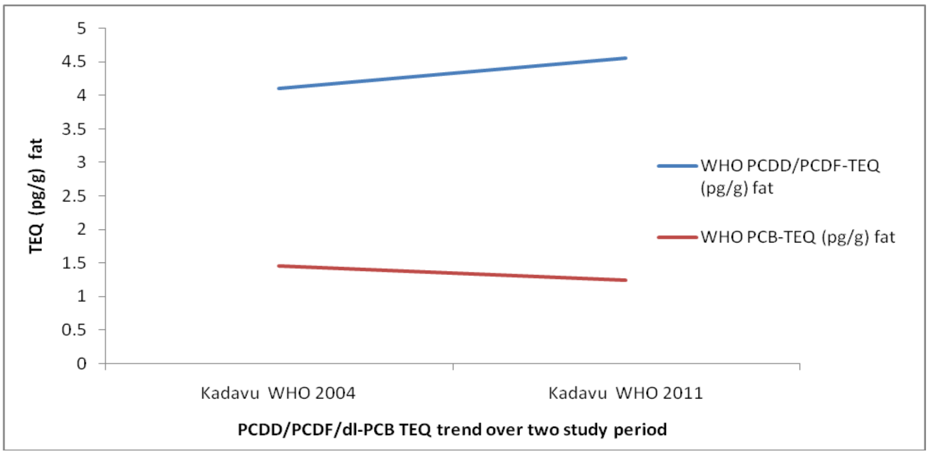

Figure 2. Trends in WHO PCDD/PCDF and WHO dl-PCB-TEQ (pg/g) in fat of human milk samples from Kadavu, Fiji

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