

PCDDs, PCDFs, AND DIOXIN-LIKE PCBs IN HUMANS AND WILDLIFE SAMPLES FROM INDIA

Kurunthachalam Senthil Kumar¹, Kurunthachalam Kannan², Odathurai N. Paramasivan³, Vellakovil P. Shanmugasundaram⁴, Junko Nakanishi¹, John Paul Giesy² and Shigeki Masunaga¹

¹ Graduate School of Environment and Information Sciences, Yokohama National University, 79-7 Tokiwadai, Hodogaya-ku, Yokohama 240-8501 Japan

² National Food Safety and Toxicology Center, Michigan State University, East Lansing, MI 48824, USA

³ Kovai Medical Center and Hospitals, P.B. No. 3209, Avinashi Road, Coimbatore 641014, Tamil Nadu, India

⁴ K. G. Hospital and Post Graduate Medical Institute, Arts College Road, Coimbatore 641018, Tamil Nadu, India

Introduction

During the twentieth century, production and use of toxic chemicals has increased rapidly thousands of chemicals have been introduced into the environment. Among them, organochlorine pesticides have received considerable attention in the last few decades because of their extreme persistence, bioaccumulation and toxic potential. These compounds are also detected at high concentrations in human tissues¹. Particularly, polychlorinated dibenzo-*p*-dioxins (PCDDs), dibenzofurans (PCDFs) and non- and mono-*ortho*-substituted polychlorinated biphenyls (dioxin-like PCBs) elicit significant toxic effects such as body weight loss, thymic atrophy, chloracne, impairment of immune responses, carcinogenesis and adverse reproductive effects to wildlife as well as laboratory animals². Therefore, these chemicals deserve a special attention in view of public health protection. India is one of the largest producer and consumer of various organic pesticides among Asian countries^{3,4}. Despite, the continuing usage, there is no study demonstrated PCDD/DFs pollution in this country. Therefore, this study reports the concentrations of PCDDs/DFs in humans, fish, meat and wildlife samples from India for the first time.

Materials and Methods

Sample collection. Fish samples were collected from various locations (Bhavani Sagar Dam and Chennai of southern part of India, Patna and Farakka of River Ganges in northern part of India) during March 1994, 2000 and February 1997. Animal fat samples (goat, lamb and country chicken) were collected from local markets in Coimbatore-district, southern India in March 2000. Liver and blubber of Ganges River dolphins (*Platanista gangetica*) found drowned in fishing nets were collected from Chappra and Patna in 1994 and 1996. Bird samples were obtained in March 2000 from nomadic tribes in Coimbatore. Human fat tissues (10 males and 11 females) were collected from volunteers with consent during biopsies performed at Kovai Medical Center and K.G. Hospital in Coimbatore. Tissue samples collected include 18 adipose fat, one thigh fat, one shoulder fat and one breast fat.

Analysis. Liver and muscle tissues of birds, Ganges River dolphin and fishes were freeze-dried prior to analysis. Moisture content was determined from an aliquot of the samples. Human fat, dolphin blubber and animal fat samples were ground with sodium sulphate and then extracted. Details of the analytical procedures have been reported elsewhere⁵. Identification and quantification of 2378-substituted congeners of PCDD/DFs and dioxin-like PCBs (non- and

mono- *ortho*- substituted congeners) was performed by use of a Hewlett Packard 6890 Series high-resolution gas chromatography interfaced with a Micromass Autospec - Ultima high-resolution mass spectrometer.

Results and Discussion

Concentrations of PCDDs and PCDFs in fishes from India varied from 9.5 to 82 and from 2.9 to 48 pg/g, on a fat weight basis, respectively (Table 1). The sum of concentrations of twelve dioxin-like PCB congeners in fishes ranged from 2200 to 33000 pg/g, fat wt. Concentrations of PCDDs and PCDFs in animal origin foods (country chicken, lamb and goat) ranged from 11 to 19 and 3.2 to 5.4 pg/g, fat wt, respectively (Table 1). Sum of concentrations of 12 dioxin-like PCBs in meat products ranged from 110 to 270 pg/g, fat wt. Concentrations of PCDDs were higher than PCDFs in fish and meat. The observed pattern of PCDD/DFs in fish suggested various sources like PCP and, chlorine bleaching and pulp mills⁶. Presence of range of PCDD/DF congeners (Fig.1) at low

Table 1. Sum of PCDD/DFs¹ and dioxin-like PCBs² (pg/g fat weight) in wildlife samples and humans of India.

| Category | Sample | 2378- PCDDs | 2378- PCDFs | Non-ortho PCBs | Mono-ortho PCBs | TEQ ^a |
|-----------------|-----------------------------------|------------------|----------------|-------------------|---------------------|------------------|
| Fish | BSD (<i>I</i> =4) ^b | 32 | 0.5 | 210 | 3900 | 8.1 |
| | Chennai (<i>I</i> =2) | 7.4 | 1.3 | 148 | 2000 | 6.8 |
| | Patna (<i>I</i> =7) | 82 | 48 | 1200 | 15000 | 32 |
| | Farakka (<i>I</i> =6) | 40 | 17 | 690 | 32000 | 7.4 |
| Meat | Chicken | 9.8 | 1.6 | <9.0 | 110 | 1.4 |
| | Lamb | 13 | 5.4 | <10 | 270 | 6.4 |
| | Goat | 19 | 4.0 | <12 | 200 | 3.8 |
| Dolphins | Liver (<i>n</i> =2) ^c | 50-220 | 24-200 | 620 (220-1000) | 65000 (8200-120000) | 70 (20-120) |
| | Blubber (<i>n</i> =2) | 15-35 | 11_19 | 370 (200-540) | 38000 (11000-67000) | 28 (26-32) |
| Birds | Eagle | 24 | 19 | 310 | 9700 | 45 |
| | Prairie kite | 240 | 130 | 820 | 36000 | 240 |
| | Osprey | 200 | 150 | 1100 | 71000 | 260 |
| | Black-winged kite | 97 | 59 | 2100 | 13000 | 200 |
| | SO [muscle] | 270 | 160 | 720 | 25000 | 150 |
| | SO [liver] (<i>n</i> =3) | 1800 (1300-2700) | 860 (620-1000) | 7600 (4900-48000) | 48000 (25000-88000) | 1400 (1100-2000) |
| Humans | Females (<i>n</i> =11) | 590 (220-1300) | 26 (9.6-64) | 230 (60-680) | 7600 (640-40000) | 30.2 (16.0-56.7) |
| | Males (<i>n</i> =10) | 440 (170-1200) | 33 (11-80) | 190 (34-630) | 8600 (2400-36000) | 29.9 (13.6-44.2) |

^{a, b} and ^c respectively toxic equivalency (pgTEQ/g fat weight) after WHO-TEFs, individual of species pooled and number of samples.

¹ and ², respectively, 2378-chlorine substituted congeners of PCDD/DFs and IUPAC numbers of 81, 77, 126, 169, 105, 114, 118, 123,

156, 157, 167, 189 PCBs; BSD and SO, denotes Bhavani Sagar Dam and Spotted owlet, respectively.

concentrations in meat products suggests generic sources derived from atmospheric deposition.

Concentrations of total PCDDs/DFs in liver and blubber of dolphins were 74-420 and 26-54 pg/g, fat wt, respectively (Table 1). Concentrations of dioxin-like PCBs varied between 66000 and 3800 in liver and blubber, respectively. Greater than 95% of the concentrations of dioxin-like PCBs were contributed by mono- *ortho* congeners in dolphins. Concentrations of PCDDs/DFs in the muscle of spotted owlet were the highest (430 pg/g fat wt) followed in decreasing order by prairie kite (370 pg/g fat wt), osprey (350 pg/g fat wt), black-winged kite (160 pg/g fat wt) and eagle (43 pg/g fat wt) (Table 1). Greater concentrations of dioxin-like PCBs have been noticed in osprey, prairie kite, black-winged kite, spotted owlet and eagle muscle. However liver of spotted owlet contained 10-20 times higher concentrations than the muscle of same species. Presence of a variety of congeners (Fig.1) in dolphins and birds suggest multiple sources including incineration, PCP and sewage disposal⁷.

Concentrations of PCDDs/DFs in 18 adipose fat, one breast fat, one thigh fat and one shoulder fat of humans from southern India ranged from 170 to 1300 pg/g, fat wt (mean: 540 pg/g, fat wt). Dioxin-like PCB congeners including non-*ortho* PCBs were detected in most of the human fat tissues (Table 1) (Fig.1) with greater levels than PCDD/DFs. Among PCDDs, 1234678-HpCDD and OCCD were the most abundant congeners (Fig.1) in humans and these results suggested PCP related sources might have influenced the exposures. Relatively lesser concentrations of PCDFs than PCDDs may be due to metabolism and therefore the shorter half-lives of the former than the latter⁸.

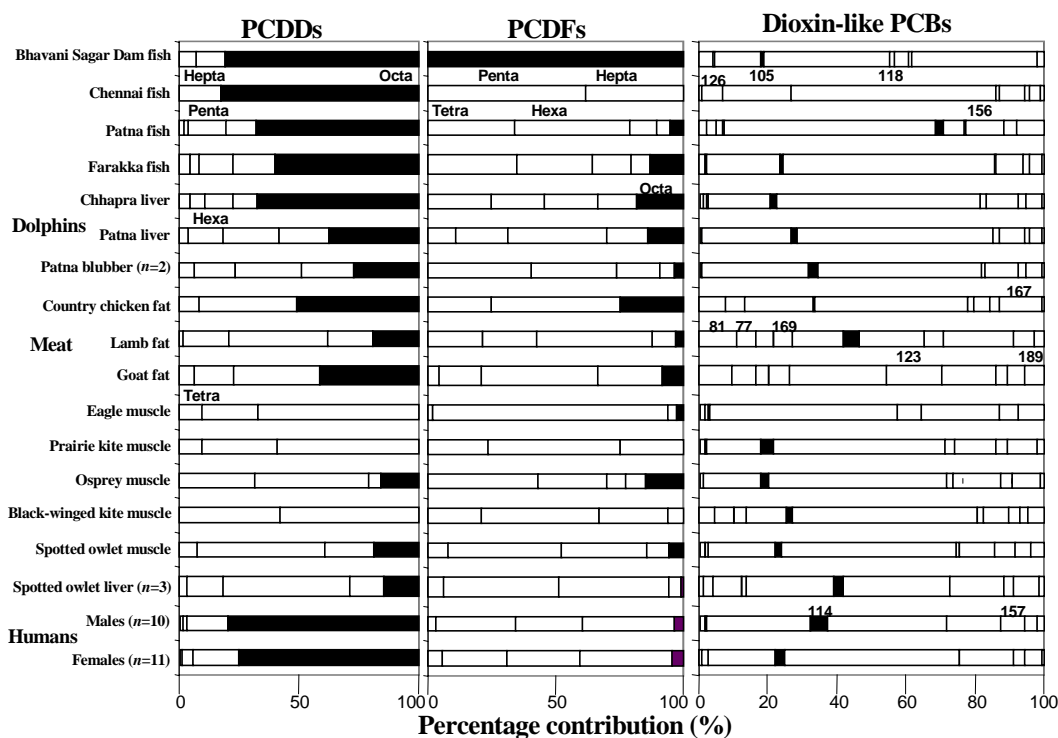


Figure 1. PCDD/DF homologues and dioxin-like PCB congener pattern in Indian fish, animal meat, dolphins, birds and humans.

Toxic Equivalents. Concentrations of TEQs (after WHO-TEFs) in fish and meat ranged from 1.9 to 18 and from 1.4 to 5.3 pg/g, fat wt, respectively (Table 1). Concentrations of TEQs in Ganges river dolphin tissues ranged from 20 to 120 pg/g, fat wt respectively (Table 1). Birds showed elevated concentrations of TEQs ranging from 45 to 260 pg/g, fat wt, in muscle and 1100 to 2000 pg/g, fat wt, in liver, respectively (Table 1). Concentrations of TEQs in humans were from 14 to 46 pg/g, fat wt, in males and 16 to 57 pg/g, fat wt, in females respectively (Table 1). PCDD/DFs contributed greater TEQs when compared to dioxin-like PCBs in several samples respectively (Fig.2). This suggests that contamination by PCDD/DFs deserves considerable attention. In general contamination by PCBs is relatively less in India^{9,10}. Observed concentrations of PCDD/DF and dioxin-like PCBs in fish, meat, dolphins and birds are lesser than USA and Japan.

However the concentrations in humans were greater than those from China, Korea, Russia and some European countries.

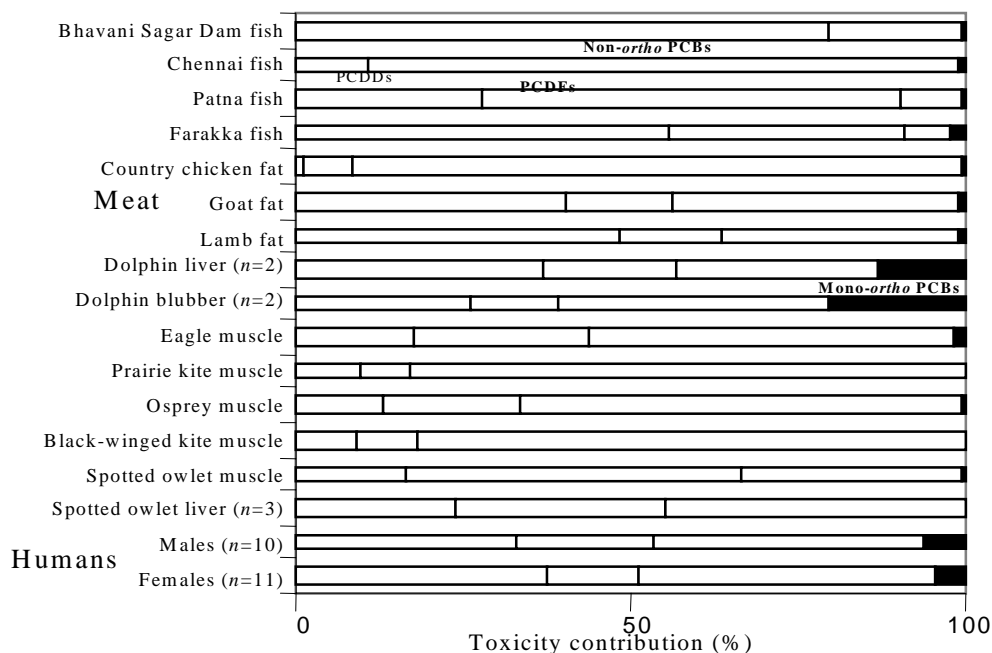


Figure 2. Toxicity contribution in terms of WHO-TEQ by PCDD/DFs and dioxin-like PCBs in Indian fish, animal meat, dolphins, birds and humans.

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