DIOXINS IN VIETNAM

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Introduction

Dioxins can be origin from many sources. Vietnam was known as an under developing country in terms of industry as well as agriculture. Recently, Vietnam runs an economic developing process with a high race. Therefore, the environmental pollution caused by chemicals resulted from industrial, agriculture activities; urbanization has been occurring and becomes a great concern. Toxic chemicals include dioxins are also produced by those activities. Furthermore, from 1961 to 1971 during the War, Vietnam was affected by the widespread spraying of the chemical defoliants Agent Orange[1], containing the most toxic dioxin congener 2,3,7,8 TCDD. Due to the high adsorptive property and persistency, dioxins are accumulated and remain in environment for a long time. At some former US Military airbases where were loaded, mixed and transported of herbicides for "Operation Ranch Hand" (1961-1971), concentrations of 2,3,7,8 TCDD were found to be very high, up to 48.130ppt TEQ (in soil), 3.565ppt TEQ (in sediment) and 1.230ppt TEQ (in human blood). These specific locations are called the "dioxin hotspots" in Vietnam.

Through the research on data of dioxins, the objectives of this study are to estimate the dioxin contamination status from different sources and to understand the characteristics of its existent sources in Vietnam.

From the results, it's apparently the dioxin contamination caused by a several man-made sources, such as: industrial process, incineration of waste... however, dioxin from the war is still a primary source compared to other sources. It indicated that the chemical war had caused a dioxin disaster in Vietnam; even now its consequences for human health and the environment, nearly 40 years after the war ended, are still a big problem. Therefore, the solutions to solve dioxin contaminated areas are quite needed.

Materials and Methods

In this paper, available data of the research on dioxin contamination status conducted by Vietnamese and international scientists since 1980s of twentieth century until now, was used. To understand the dioxin from the war, data is focused of locations which herbicides sprayed and loaded in southern Vietnam during the war. For dioxins of other man-made sources, data of investigate reports was collected from the industrial zones, agricultural and urban activities in whole country.

Results and Discussion

I. Dioxin from the war

Figure 1: Military bases in the Operation "Ranch Hand"

According to Stellman[1], during the period from 1961 to 1971, the U.S. Military had sprayed 77 million liters of herbicides over 2.63 million hectares of South Vietnam, of which 51.6 million liters of substances contained dioxin (67%) with 366 kg of dioxin over 1.68 million hectares. Consequently, more than two million hectares of forests were devastated by the effects of the herbicides used at high concentrations[2]; the health of millions of people was severely affected under long impact of dioxin. At locations where the U.S. Military used as serve for Operation Ranch Hand such as the airbases: Bien Hoa, Da Nang, Phu Cat (Figure 1) residues of dioxin has been very high, known as hotspots of dioxin war in Vietnam.

In order to assess the residues of dioxin, it is necessary to distinguish 2 types of areas: Sprayed Areas (SA) and Storage-Loading-Washing Areas (SLWA).

1. 1. Dioxin in Sprayed Areas (SA)

a. In soil and sediment : The obtained results on dioxin residues by GC/MS are presented in Table 1.

Table 1.Residues of dioxin in the sprayed areas [3,6,9,21]

b. In Blood (Table 2)

No	Area	Time	Soil		Sediment	
			n	C, ppt TEQ	n	C, ppt TEQ
1	Gio Linh-Cam Lo	2003-04	31	1,2	15	1
	Quang Tri	2004	10	20	-	-
2	A Luoi, Thua Thien - Hue	1996-99	99 2	26 879	20	6
3	Phu Lộc, Thua Thien - Hue	1993	4	8,6	-	-
4	Kon Tum	2003	14	0,2	6	0,4
5	Tay Ninh	1993-98	38	14	-	-
6	Rung Sac, HCM	1986-90	7	16	-	-
	Tan Son Nhat, HCM	1995-96	7	4	-	-
	Tan Son Nhat, HCM	2006	-	-	5	2-341
7	Ca Mau	1993	16	<1	-	-
8	Tri An, Dong Nai	2002-03	15	2,2	27	2,9
9	Ma Da, Dong Nai	2000	9 1	10,2 122	-	-
10	Phan Rang airport	2004	5 1	24 265	-	-
11	Tan Uyen, Binh Duong	1995-98	19	15	-	-
12	Bu Gia Map, Binh Duong	2008-09	153 2	6,2 200	10	4

Table 2: Dioxin concentration in residential blood in different areas[3,9,13]

Note: T% = (TCDD concentration/ TEQ) x 100

Area	n	TCDD, ppt	TEQ, ppt	T%	Time
Exposed areas to Agent Oranges/dioxins					
The whole of South Vietnam	2.492	9	36	27	1991-1992
Key areas in Vietnam	233	18,8	32	57,7	1993
Unexposed areas to Agent Oranges/dioxins					
North Vietnam	82	2,7	20	13,5	1993
The World	1.234	3,5	24,7	15,3	before 2000

c. In breast milk : Concentrations of dioxin in breast milk in sprayed areas were gradually declining from 1970 to 1999 to the approximate level in comparison with the average level of the World in 2003.

Table 3: Comparison of dioxin levels in breast milk in Vietnam with the world[3,9,19]

Location	Time	dioxin concentration, ppt-TEQ/lipid
South Vietnam	1970	485
	1973	161
	1986-87	20
	1999	12,3
Hanoi	1986-87	8,8
The World	2003	10

d. In adipose tissues

Analytical results of 149 adipose tissue samples from people in North and South Vietnam[9] show that the average concentration of TCDD in 114 samples in South Vietnam was 17.5ppt, of about 10 times higher than that in the North Vietnam (1.7 ppt).

These results demonstrate an important fact that, even in the same region residential people exposed to toxic chemicals containing dioxin (Agent Orange), dioxin levels in their bodies are very different, with the highest level up to 130 ppt. Therefore, it can be confirmed that the effects of this toxin causes on different individuals vary significantly. This conclusion is highly agreement with the scientific finding that impact mechanism of dioxin in humans depends on have different body sites.

1.2. Dioxin in Storage – Loading - Washing areas (SLWA)

In the war time, the U.S. military have mainly used teen airbases, excluding land zones in South Vietnam. They has brought 382,175 barrels contained 208 liters of herbicides (correspondingly to 79.5 million liters) to the airbases in Bien Hoa and Tan Son Nhat, Da Nang, Nha Trang and Phu Cat[8]. Three airbases of Bien Hoa, Da Nang and Phu Cat were main places of storage and loading to the aircraft for spraying and washing after spraying. The remains were transit places, such as Tan Son Nhat and Nha Trang. Noting that, from December 1969 to March 1970, in Bien Hoa airbase it happened four times of leakages of 25,000 liters of Agent Orange and 2,500 liters of Agent White to surrounding areas of the tanks[7].

Table 4: Volume of herbicides transferred to storage at the former military airbases[7]

Airbases	Agent Orange	Agent White	Agent Green	Other agents	Total
Tan Son Nhat	57.000	17.000	4.200	14.075	92.275
Bien Hoa	98.000	45.000	16.300	-	159.300
Da Nang	52.700	29.000	5.000	-	86.700
Phu Cat	17.000	9.000	2.900	-	28.900
Nha Trang	9.000	4.900	1.100	-	15.000
Total	233.700	104.900	29.500	14.075	382.175

From 1992, the army scientists of Vietnam has been carried out many surveys of Agent Orange /Dioxin residues in the airbases with a focus on Bien Hoa, Da Nang and Phu Cat. By the end of 2007, residues of dioxin had been determined at seven airbases, and identified three "hotspots" of Bien Hoa, Da Nang and Phu Cat airbases as the most dioxin contaminated areas. The following researchs in the years from 2008 to 2009 [4,5,6] were added more detail data to confirm these hotspots.

Table 5: Average dioxins concentrations in soil and sediment at the airbases[4,5,6]

No	Airbase	Dioxin/ Soil ppt TEQ	Dioxin/Sediment ppt TEQ
1	***Bien Hoa***	***35.865***	***300-2.800***
2	***Da Nang***	***48.130***	***3.565***
3	***Phu Cat***	***37.000***	6-86
4	Pleiku	22	4
5	Nha Trang	63	14
6	Tan Son Nhat	10	116
7	Can Tho	57	19

The data in Table 5 shows that dioxin levels in soil of contaminated sites at three airbases of Bien Hoa, Da Nang and Phu Cat are 36, 48 and 37 times higher than threshold standard of Vietnam [4,5,16] , respectively. While in sediments at the airbases of Bien Hoa and Da Nang, dioxin levels are 18 and 24 times higher, respectively. These are intensively contaminated sites, where suitable treatments are required. In the "dioxin hotspots", the levels of dioxin in residential blood are also higher than those in the sprayed and comparative areas (Table 5).

Table 5: Comparison of dioxin levels in human blood of the loaded and the sprayed areas [9,10,11]

Location	n	TCDD, ppt	TEQ, ppt	T%	Time
North Vietnam (in comparative areas)	82	2,7	20	13,5	1993
The whole South Vietnam	2.492	9	36	27	1991-1992
Key areas in South Vietnam	233	18,8	32	57,7	1993
Bien Hoa city	43	93,8	-	-	1999-2001
Trung Dung hamlet, Bien Hoa	20	70,2	83,3	71,1	1999
Area surrounding Lotus lake/Bien Hoa airbase	22	222	265	68	2006-2009

Data in Table 6 shows the tendency of dioxin levels of in human blood in different areas as follows: hotspots areas> sprayed area > comparative areas. This demonstrates the negative impact of dioxin for the health of residents in the hotspots and its surrounding are of great concern. Regarding the half-life of TCDD is 7.6 years, and then their concentrations in blood of peoples living in sprayed areas have fallen near to those levels in comparative areas. While in the hotspot, those data still shows very high values. It is needed to continue research, monitoring and applying appropriate policies.

II. Dioxin from other man made sources: Documents from UNEP[16] reported the amount of dioxins in Vietnam in 2002, as follows:

Air:	15, 97 g TEQ/year	Products:	2, 19 g TEQ/year
Water:	1, 46 g TEQ/year	Wastes:	48, 16 g TEQ/year
Soil:	1, 05 g TEQ/year	Total:	68, 83 g TEQ/year

a. Dioxins in air: Elevated concentrations were found in traffic intersection places with a large number of vehicles. Data obtained in 1999 – 2000[7,13]as follows: In Hanoi: Nga Tu So Cross: 0.85 pg TEQ /m^3; ticket station on Chuong Duong Bridge: 0.2 pg TEQ /m^3; Bat Trang production zone: 0.4 pg TEQ /m^3. In Ho Chi Minh City: Democracy Cross: 0.4 pg TEQ /m^3; Phu Nhuan Cross: 1.2 pg TEQ /m^3. In areas with other sources of emissions, concentration of dioxin in the air is very low: Pha Lai Power plant: 0.5 pg TEQ /m^3. However, in areas without any direct source of emissions, the concentration of dioxin is found at less than 1 femtogram/m^3 [14].

B.In soil: In the years 1989-1995 data showed that 2, 3,7,8-TCDD was not detectable in the 13 soil samples taken at the Hanoi1[3]. However, in the years 2000 -2002, it was found dioxin concentration ranging from 125 to

50500 (ng/g dry wt) and from 21 to 880(ng/g dry wt) in soil samples from the wastes dumping sites in Hanoi and Hochiminh city, respectively[13] .

c. In sediment: Ma river (Thanh Hoa): 0.7ppt TEQ; Lam river (Nghe An): 0.5ppt TEQ[6].

For comparison, dioxin levels in soil and sediment reported in the Europe as follows: for soil, sediment dioxin levels are in range of <1-100ppt; for air, dioxin levels are in range of <1 - 100 fg / m^3 [18].

III. Different characters of dioxin from the war and other man –made sources

In order to understand characteristic of dioxin sources, Vietnamese scientists had studied over 1000 samples collected in sprayed/loaded areas and industrial zones in Vietnam as well as in other countries. The results suggested that the characteristics between dioxin from the war and those from other man-made sources are the different pattern of congener profile[22]. Moreover, two factors of the percentage of 2,3,7,8 TCDD concentration in TEQ (as T %) and concentration ratio of 1,2,3,7,8 PCDD and 2,3,7,8 TCDD (as P) [20] can be used for recognize of those sources. It shows that the T% are bigger than 50% and ratio P are less than 1 in samples of dioxin from herbicides, while, it always received opposite values as T%<50% and P<1, in samples of industrial or waste combustion process[23] .

IV. Remarks

1. Dioxin concentrations in environment in North Vietnam are very low. These can be used as the background level to compare to the South. In South Vietnam, 40 years after the Operation "Ranch Hand", dioxin levels in the SA has slowly decreased, but in the SLWA of the former airbases where were used for the Operation Ranch Hand, dioxin concentration in soils and sediment are 40-50 times and 18-24 times higher than acceptable threshold (1,000 ppt TEQ and 150 ppt TEQ), respectively [4,5 6,17]. Dioxin levels in human blood in such areas are 15 times to 50 times higher than those in North Vietnam.
2. Until now, the research results of international and Vietnamese scientists indicates that dioxin in Vietnam mainly associated with the use of defoliants by the U.S. military during the war. It is confirmed about existence of three dioxin hotspots in South Vietnam. It is highly toxic contaminated sites in three airbases of Bien Hoa, Da Nang and Phu Cat about totally 264,000 tons of soil and sediment must be urgent treated.
3. Besides the requirement to remediation of the dioxin hotspots, the health care of millions of victims of Agent Orange/Dioxin in Vietnam has been particularly concerned. This long term problem is to be step by step resolved and need supported by the International Community.

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