

THE ENVIRONMENTAL AND HUMAN HEALTH ISSUES AT THREE “DIOXIN HOTSPOTS” OF VIETNAM

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Abstract

Today in Vietnam, there are specific locations called “dioxin hotspots” where concentration of dioxin 2, 3, 7, 8-TCDD found to remain very high, despite the war passed of over three decades. The “dioxin hotspots” are located in and around the former US airbases of Been Hoa, Da Nang and Phu Cat airbases which served for Operation Ranch Hand, during the US-Vietnam War.

This paper reviews the data of recent investigation on environmental contamination and human health status of the communities living at vicinities of these three “dioxin hotspots”. The result showed the high concentration levels of dioxin in various kind of samples, even of human tissues. The result also pointed the abnormal disease pattern, birth defect and reproductive problem of the habitants living there. Due to the long-term persistence of dioxin and the high potential exposure to AO/dioxin of people by food chain transfer way, it indicated that and consequences of the chemical war are still over burden on the local peoples. Moreover, the solutions to support local peoples to overcoming these consequences are addressed in this paper.

Introduction

During the US-Vietnam war, the US Army sprayed nearly 80 million litres of herbicides, including more than 20 substances, most of which being the Agent Orange, a mixture of 2, 4D and 2, 4, 5T¹. Agent Orange was the most toxic component of chemical herbicides, principal as part of Operation Ranch Hand from 1961 to 1971 by the US military in order to deny their military enemy. It has been estimated that among 20,585 affected villages, which are recorded in database, there are 3,181 villages were directly sprayed and the exposure population were around 2.1 – 4.8 millions, 1,430 other villages were also sprayed but the exposure population data could not be evaluated¹.

Up to now, nearly 40 years after, it there are specific locations called “dioxin hotspots” where concentration of dioxin 2, 3, 7, 8- TCDD found to remain very high, particularly, at former army airports such as Bien Hoa, Da Nang and Phu Cat. According to the US reports^{1, 2}, large quantities of herbicides were stored, mixed, and loaded on aircraft for aerial spraying at Bien Hoa, Phu Cat, and Da Nang airbases. Due to the careless of their operation, a large amount of toxic herbicides was spilled, leakages into the land and water, causing considerable contamination in the airbases and its vicinities. Here dioxin concentrations in soil, sediment and bio- samples were found at hundred, even thousand time higher than the international maximum standard levels⁵⁻¹⁰. Moreover, in the vicinities of airbases, local habitants observed to have human health problem, such as: abnormal diseases, birth defect, fertility complication and others¹¹⁻¹⁹.

In order to assess the consequence of the chemical war, this paper review of the results of our recent investigation on contamination level, human exposure to AO/dioxin and implication of magnitude of contamination on human health in location surrounding airbases. The results indicate that despite passage of nearly 40 years, continued effects from the war to the habitants, especially to the people who is AO victim and their families. It also indicated the necessary to find solutions in the aspects of socio-economic, health care and technique to mitigate dioxin impacts and protect public health of local communities.

Materials and methods

Available data of the research on dioxin contaminated levels and human health implication conducted by Vietnamese and international scientists since 1980s of twentieth century until the end of 2007⁴⁻¹⁹ were used. Studied locations were focused of the vicinities of each airbase, including Trung Hoa and Trung Dung districts (near Bien Hoa airbase, Dong Nai province), Thanh Khe and Cam Le districts (near Da Nang airbase) and An

Nhon and Phu Cat districts (near Phu Cat airbase, Binh Dinh province). Moreover, during 2008, our data also resulted by other ways, such as: Interview/questionnaires to local habitants living at vicinities of airbases; Interview/discussion with the officials working in the government/non-government organization, include District's People Committees, Local Department of Health, Department of Natural Resource and Environment, Red Cross Association. AO Association, Woman association of each district as mentioned above;

Results and Discussion

1. Volume of AO/dioxin storage in three airbases

Table 1: Quantities of herbicides (litres) transported and storage in three former US Army airbases during the US-Vietnam War^{2,3}.

Name	Bien Hoa airbase		Da Nang airbase		Phu Cat airbase	
	Ranch Hand	Pacer Ivy	Ranch Hand	Pacer Ivy	Ranch Hand	Pacer Ivy
Agent Orange	20.384.000	2.288.000	10.960.000	1.709.000	3.536.000	-
Agent White	9.360.000	-	6.032.000	-	1.872.000	-
Agent Blue	3.390.000	-	1.040.000	-	603.200	-

According to US document,^{2,3} significant large quantities of herbicides were stored, mixed, and loaded on aircraft for aerial spraying at Bien Hoa, Phu Cat, and Da Nang airbases. Due to the careless of their operation, a large amount of toxic herbicides was spilled, leakages into the land and water, causing considerable contamination in the airbases and its vicinities.

Table 2. Dioxin concentration found in environmental samples collected at three "dioxin hotspots"

No.	Airbase	Samples	Dioxin concentration (ppt-TEQ)	
			Minimum	Maximum
1	Bien Hoa	Soil	35,8	58 4,5 ^{5,6}
		Soil	1000.000	^{9,10}
		Sediment	9	674 ⁴
		Sediment	797	1.164 ^{9,10}
		Duck	276	331 ¹¹
		Fish	0,063-65 ^{4,5}	and 4460-7176 ⁶
		Frog	56	^{5,6}
2	Da Nang	Soil	50	69,444 ^{4,5,6}
		Soil	899	365.000 ^{9,10}
		Sediment	1,2	75 ^{5,6}
		Sediment	1,8	6.270 ^{5,6}
		Fish	0,24	0,78 ^{5,6}
		Fish	3.000	^{9,10}
		vegetable	110,6	2.173,6 ^{9,10}
3	Phu Cat	Soil	1,76	11.376 ^{9,10}
		Sediment	6	95 ^{9,10}
		Sediment	11.400	49.500 ^{4,5}
		Fish	1,7-5,4	^{9,10}
		Snail, oyster	0	6,8 ^{9,10}

2. Environmental contamination and human exposure of Agent Orange/dioxin

From 1980s until now, many studies on the dioxin exposure in Vietnam have been carried out in the national scale of dioxin project which cooperated with international organizations such as Canada, Japan, Germany, USA, etc. and they were also sponsored by many international organizations such as UNDP, FORD, etc^{4,5,9,10}. Almost studies fall into two objectives: a) estimates of the concentration of AO/dioxin found at studied locations; b) examination of the concentration of AO/dioxin in the tissues of people who may have exposed to AO/dioxin during and after the wartime.

In these airbase area, the highest concentration of dioxin in soil was found to be to 365.000ppt, 1.000.000ppt and 49.500ppt (of which, 96-99% was TCDD) at Da Nang, Bien Hoa and Phu Cat, respectively^{4,5,10}. In sediment, dioxin concentrations were ranging from 100 - 3.371ppt. It was also found comparatively high concentration of dioxin in almost bio-samples collected in areas around these airbases, such as duck, fish, snail, oysters and frog,^{4,6,9,10}.

To understand the penetrate of dioxin into the soil, a studies on dioxin residues in depth of airbases was conducted in three airbas and showed that due to different natural and soil conditions of each contaminated areas, the movement of dioxin following depth in these locations is also different⁴. It suggests dioxin can be deeply penetrated into ground and the deepness level of dioxin penetration was depending the soil pedogenic condition at the location (Table 3).

Table 3: Concentration of dioxin found in depth of three airbases

Depth (cm)	Dioxin concentration in depth (ppt –TEQ)		
	Contaminated area Bien Hoa	Contaminated area Da Nang	Contaminated area Phu Cat
20	27,544		
30	8,186	34,213	11,367
40	5,998		
60	2,043	10,970	1,456
80	3,735		
90	991	9,933	926
100	228		
120		5,003	506
150		951	121
180			5

Some studies have determined exposure levels to Agent Orange and TCDD by analysing tissue samples^{4,12} – usually blood, breast milk, fat tissues from people who may have been exposed and compare the presence of TEQ levels to a control group who presumably were not exposed. A recent survey found evidence of elevated 2,3,7,8 TCDD levels in blood of children who have birth defect and living in vicinities of Da Nang and Bien Hoa airbases. Among these blood sample, the highest concentration of TCDD in vicinity of Da Nang was found to be 365, 99 pg/g lipid¹². Dioxin levels in human tissue samples in the control areas of Hai Phong were very low compared to those in Da Nang and Bien Hoa. A separate study of blood dioxin level of Da Nang habitants reported TCDD concentration “more than 100 times globally acceptable levels”¹⁰.

Table 4: Concentration of TCDD in human tissue of people living at airbases’ vicinities

Airbase	Tissue	2,3,7,8-TCDD concentration	Dioxin Conc (TEQ)
Bien Hoa	Whole blood	7,3 – 28 (pg/g lipid) ¹⁸	19 – 61 (pg/g lipid) ¹⁸
	Whole blood		
	Milk		
	Fat		
Da Nang	Whole blood (children)	2,1 – 57,7 (pg/g lipid) ⁴	12,4 – 365,9 (pg/g lipid) ⁴ 77 – 118 (pg/g lipid) ¹⁸
	Whole blood	14 - 19 (pg/g lipid) ¹⁸	
	Whole blood (children)	6,65 – 21,71 (pg/g lipid) ¹²	
Hai Phong (control area)	Whole blood (children)	1,5 – 6,7 (pg/g lipid) ¹²	
	Whole blood (adult)	1,07 – 1,76 (pg/g lipid) ¹²	

All given results suggest the apparent food chain transfer of dioxin from contaminated soil to cultured fish pond sediments to fish and duck tissue, then human as found in whole blood and breast milk. It also suggests that a principal route of exposure is the transfer of dioxin from the soil into the river sediment, then into fish, and from fish foodstuff into human.

3. The investigation of human health

In order to understand the human health effect, the studies have focused data on the disease pattern, birth defect and pregnant failure of local habitants of living near hotspots. The investigated results from three airbases show in below:

Table 5: Disease pattern in Bien Hoa airbase's vicinity

Disease Group	Frequency in Area 1 (%)	Frequency in Area 2 (%)	Compare (P)	List of diseases caused by AO compiled by VRC
Cardiovascular hypertonic	17,99	12,10	<0,05	+ Acute, chronic and sub- acute peripheral neuropathy; + Chloracne + Diabetes (Type2) + Hepatoma + Hodgkin's disease + Lipid metabolism + Malignant lymphoma + Porphyria cutanea (skin) + Multiple Myeloma + Prostate cancer + Respiratory cancer + Birth defect + Sarcoma; + Spinal bifida
Peripheral neuropathy	14,43	5,74	<0,05	
Nervous system				
Skeletal system	11,44	7,58	<0,01	
Dermatosises (skin)	5,85	2,52	<0,05	
Endocrine	3,73	2,72		
Tooth	3,90	2,06	<0,05	
Digestion system	8,33	5,74		
Respiration (cancer)	6,24	2,75	<0,05	
Eye	2,47	0,45	<0,01	
Nose	8,45	2,06	<0,01	
Urinary(diabetes)	4,16	2,29		
Heart rhythm abnormality	57,39	25,71	<0,05	

In a study in Bien Hoa airbase, 769 subjects living in contaminated area (Area 1) and 435 subjects living far from contaminated area (Area 2) were checked. The result showed in Table 5. The result showed the rate of diseases is higher in the dioxin contaminated area^{4, 5}. The pattern of abnormal diseases is most frequent of nervous system (Peripheral neuropathy), birth defect, digestive system, respiration cancer, and skin cancer 4, 5.

During 1998 and 2000, The Vietnam Red Cross (VRC) compiled list of diseases it associated with Agent Orange/dioxin exposure. In March 2008, Vietnam Ministry of Health declared a list of 17 disease and deformities that maintained were related to exposure to dioxin. The list by Vietnam Red Cross contained many of the same disease identified by the US. Department of Veterans Affairs as being related to exposure to dioxin (see in Table 5) including diseases of respiration cancer (bronchial carcinoma, tracheal cancer, laryngeal neoplasm), prostate cancer and type 2 diabetes. Based on it, the result indicated that people living in the areas near 'dioxin hotspots' have certain diseases which are recognized as being related to dioxin exposure.

The pattern of birth defect (reproductive abnormalities)

Recent studies demonstrate that there are 13 item of birth defect which appears frequently in children living at vicinities of Bien Hoa, Da Nang and Phu Cat airbases⁵. High rate of birth defect found in *Nervous system*, cerebral, the next is hare lipped and then death, congenital heart, paraplegia^{15,16}.

Other investigation in vicinities of Da Nang airbase have also found that birth defect rate is high in the first child, age of mother is under 35 and birth defect is also prevalence in F2^{5,16}.

Result from a recent research in Bien Hoa airbase and Hanoi in 2004¹³ indicated that rate of prevalence of disease at vicinity of Bien Hoa is 3,1/person and rate of diseases of nervous, circulation, digestive, skin and muscle. This rate had higher than those in Hanoi (as 0, 9%/person). Rate of spontaneous abortion is 2, 3 times higher than in Hanoi. Rate of fertility complications (spontaneous absorption and fetus death) is 17, 1 %. Rate of birth defect of Been Hoax airbase's vicinity is 10, 3 times higher than in Hanoi (P<0, 01) and 15, 4% families have 2 children with birth defect^{13,1}

Table 6: Pattern of birth defect in three hotspots

Birth defect group	Rate (%)		
	BienHoa (in 383 child.)	DaNang (in 377 child.)	Phu Cat (in 669 child.)
Cerebral	<u>23,2</u>	<u>34,2</u>	<u>33,33%</u>
Hare lipped	<u>18,3</u>	<u>10,9</u>	<u>8,33</u>
Down	5,0	10,6	0-
Death	<u>8,4</u>	<u>7,2</u>	<u>12,5</u>
Congenital heart	<u>9,9</u>	<u>6,7</u>	<u>4,16</u>
Paraplegia	5,1	4,5	0-
Eyes, blind	4,9	4,5	8,33
Defected upper/lower limb	<u>10,5</u>	<u>7,6</u>	<u>16,16</u>
Defected ears	1,6	2,9	0
Spinal column	0,8	2,4	12,5
Blood diseases	0,8	1,1	0-
Defect short	1,6	0	4,16

The fertility complication status

In vicinity of Bien Hoa airbase, a survey on 445 women in contaminated area and 261 women in control area, showed that rate of fertility in contaminated area was 36,16% (control area was 14,44%)($P < 0,05$). spontaneous abortion was 16,38% (control area was 11,11%) ($P < 0,05$); rate of light weight ($< 2,5\text{kg}$) was 5,08% (control area is 1,11%); mole was 2,26% (control area is 0%)¹⁸.

A study conducted Phu Cat found that the rate fertility complications (RFC) of female veterans and wife of male veterans to total number of pregnancy was 41,27% (control: 27,17%; $P < 0,01$). RFC of daughter in law of veterans: RFC/ number of pregnancy: 36,07% (control: 27,85%). Prevalence of fertility complications were spontaneous abortion, mole, miscarriages, fetus death, stillbirth^{17,18}.

A research on 47.893 veterans in 8 provinces that were representative of the whole country, who participated in war in the South of Viet Nam before 1975¹⁷. By checking cross-sectional study and clinical examinations and preclinical examinations showed that rate of diseases relating to dioxin in exposed group is significantly higher than control group ($P < 0,01$). Birth defects and fertility complication in F1 and F2 is significantly high¹⁷.

In addition, to understand the harmful effect of Agent Orange a study on infertility statement has conducted in 8 communes in Phu Cat district and 3 communes in Thanh Khe district which are vicinities of Phu Cat and Da Nang airbases. 13.563 couples were checked results of this study show that: 1). The rate of infertility is: 1,31%. 2. In infertile couples 66,67% male partners had semen abnormality (the rate of male was not demonstrable abnormality: 33,33%). 3. High ratio of azoospermia and high ratio of oligospermia had been found in infertile male partners who lived in Phu Cat and Thanh Khe Districts: zoosperm: 29,24%, oligospermia: 27,78%. Others semen aberration were found: low motility: 29,41%, low ratio of living spermatozoid: 11,76% and teratozoospermia: 7,84%¹⁹.

Regarding to toxicological effect of dioxin to human, many researches have pointed out the abnormal phenomena of acute/chronic abnormal diseases and the evidences of effect on respiratory system, immune system, reproductive system and genetic^{20,21}.... Therefore, our investigated results indicate that AO/dioxin is harming the health of local people in several ways. First, Vietnamese people and soldiers who were directly exposed to AO/dioxin during the war experiencing certain diseases and health problem at a rate higher than the people's unexposed population. Second, people living in "dioxin hotspots" with high residual dioxin in the soil, sediment and water are also suffering from health complication related to the aftereffects of Operation Ranch

Hand. Third, the children of people living around the “dioxin hotspots” are exposed to dioxin and have unusually high level of birth defects and health problems.

After the War, Vietnamese government has very much concerned on the effect of Agent Orange/ dioxin on environment and human health in contaminated areas, especially of dioxin hotspots and decided the policies to aid people to overcoming of consequence of the war. For people in ‘dioxin hotspots”, the solutions to support them are proposed and discussed as followings:

- Clean up of dioxin from the identified “dioxin hotspots”;
- Research on remediation technologies for dioxin contaminated soil
- Awareness to improve knowledge of community, and on prevention from exposure to dioxin;
- Organizing centres of care, clinical and rehabilitation of AO victims; develop model of caring, and supporting the victims; program to train health workers, educators, parents and other care for disabilities.
- Develop Model of support directly to victims and their family at home; Model of home caring and day-boarding for children; Model of general support at community level.
- Government need to build a National plan for overcoming of the War’s consequence.

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