

THE AGENT ORANGE DIOXIN ISSUE IN VIET NAM:

A MANAGEABLE PROBLEM

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Introduction

Since the early 1990's, Hatfield Consultants Ltd. (Hatfield) and the 10-80 Division, Ministry of Health (10-80) investigated the impacts of Agent Orange dioxin on the environment and human populations in several provinces of Viet Nam.^{1,2} As early as 1970, a number of Vietnamese and international researchers have contributed to our understanding of Agent Orange impacts in Viet Nam.³⁻⁹

In 1962, the US military initiated use of herbicides in Viet Nam for general defoliation and crop destruction through a program codenamed Operation Ranch Hand.¹⁰ Application of herbicides was primarily through cargo aircraft, and ground mechanisms; helicopters were also used in certain areas of the country. More than 80 million litres of herbicide were applied over approximately 10-12% of southern Viet Nam.^{11,12} This figure was recently revised to over 80 million litres.¹³ Herbicide applications ceased in 1971.

Military installations throughout southern Viet Nam (e.g., Bien Hoa, Da Nang, Nha Trang, and Phu Cat) served as bulk storage and supply facilities for Agent Orange.¹⁴⁻¹⁶ Herbicides are known to have been spilled at these sites. In 1970, for example, a 7,500 US gallon spill of Agent Orange occurred on the Bien Hoa base; between January and March 1970, three other spills of lesser volume occurred at Bien Hoa.¹⁶

As a consequence of aerial applications and handling of Agent Orange at US military installations, two primary sources of 2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD) contamination in Viet Nam have been identified: spray missions by C-123 aircraft, and contamination at former US military installations where herbicides were stored and deployed.

10-80 Division and Hatfield theorize that the pattern of TCDD contamination recorded in Aluoi District (Thua Thien Hue Province) serves as a model for contamination throughout southern Viet Nam.¹ Direct human exposure during the war, and subsequent ongoing contamination through food chain transfer of TCDD, are expected to be highest in areas adjacent to former US military installations where elevated concentrations of TCDD may still be residing in soils, particularly as a result of herbicide spills, washing out herbicide tanks, and high volume ground applications.

Soils in regions aerially sprayed did not have the same loading of Agent Orange, and therefore TCDD, as military bases.

The principal concern today, regarding dioxin in the environment of Viet Nam, is that people living near some former US military installations continue to be exposed to dioxin. People born after the war

are also at risk of contamination. Through the use of dioxin-laden herbicides, the Viet Nam War has left a legacy of environmental contamination that continues to this day; however, with simple mitigation measures this problem can be addressed and the probability of exposure significantly reduced.

Materials and Methods

Between 1996 and 2004, over 250 samples of soil, aquatic sediment, foods, whole human blood and human breast milk were collected and analyzed from a number of locations in Viet Nam, including areas aerially sprayed with herbicides during the American-Viet Nam War. Sampling sites included remote districts in Viet Nam (e.g., Aluoi District), and downstream of former US military installations (e.g., Bien Hoa, Da Nang, Phu Cat and others).^{1,2}

Field supplies for sample collection, storage and shipment originated in Canada. A stainless steel soil corer was used to collect soil samples. A landmine detector was used to ascertain that sampling locations were free of unexploded ordnance. Each tested soil sample was a composite of 10 subsamples. Subsamples were collected within a 30 m radius of the primary site. All samples were placed in pre-cleaned glass jars with Teflon lids and frozen. Following collection of each core, equipment was rinsed with acetone and hexane to prevent cross contamination. A grab sample constituted a sediment sample in aquatic systems.

All samples from Viet Nam were forwarded in a frozen state to AXYS Analytical Services, British Columbia, Canada. For the earlier studies, total toxic equivalents for each sample analyzed were calculated in the laboratory using the “international” dioxin toxic equivalents.¹⁷ More recent studies applied the revised WHO TEF units.¹⁸

High resolution GC/MS was performed on samples for detection of dioxins and furans. For non-detectable (ND) and NDR (chromatographic peak was detected, but did not meet quantification criteria) designations, ½ the detection limit of the sample was used in the Total-TEQ calculation.

Results and Discussions

After over a decade of research, the 10-80 Division (Viet Nam) and Hatfield Consultants Ltd. (Canada) have concluded that residual levels of wartime Agent Orange dioxin (TCDD) in soils of southern Viet Nam are generally at or below background levels found in industrialized nations of North America. However, 10-80/Hatfield research has shown that significant hot spots of TCDD remain in select areas of southern Viet Nam.

Studies in the vicinity of the former Aso US military base in Aluoi District demonstrate that TCDD contamination has spread from soils to humans via the food chain.² Soils from heavily contaminated areas remain a reservoir/source of TCDD, and warrant the term ‘primary hot spot’. The fact that food, human blood and breast milk in the Aso Commune were found to have elevated dioxin concentrations, relative to aerially sprayed regions of the valley, creates concern related to nutritional and public health issues. Results from the Aluoi District study emphasize that

former US military bases should be the primary sites on which to concentrate further studies and direct remediation measures, thereby helping reduce potential TCDD exposure for local Vietnamese.

Schechter et al. sampled near the former US Bien Hoa base, and measured high levels of TCDD in soils (e.g., 1,164,699 pg/g dry weight) and in human blood (e.g., 271.1 pg/g lipid).⁸ These levels may be related to Agent Orange spill(s) at Bien Hoa in 1970.¹⁵ Additional studies near Bien Hoa found elevated levels of TCDD in human blood.⁹ Schechter et al. reported 2 pg/g TCDD in pooled blood from

a Ha Noi control group.8 These data support the theory that contamination hot spots are located near former US military installations.

The former US airbases at Da Nang, Phu Cat and Bien Hoa may be categorized as significant dioxin 'hot spots' on the basis of the TCDD concentrations recorded in areas 'downstream' of suspected Ranch Hand sites. Suspected 'primary sites' were not sampled directly in this study due to restricted access by Vietnamese authorities. However, the elevated TCDD values (Table 1), suggest significant involvement of Agent Orange herbicide in the overall toxicity of these soil/sediment samples, given that TCDD was the characteristic dioxin congener in Agent Orange.

Table 1. Range of Total TEQ values (pg/g dry weight) and maximum TCDD levels (pg/g dry weight) of soils and sediments near former US military installations in southern Viet Nam (N=number of samples analyzed), collected in March 2005.

	TOTAL		MAXIMUM	
	N	TEQ (pg/g)	TCDD (pg/g)	
<i>Da Nang</i>	21	<1 – 269	227	(soil)
<i>Pleiku</i>	13	<1 – 64.2	53.4	(soil)
<i>Phu Cat</i>	18	<1 – 201	194	(sediment)
<i>Nha Trang</i>	5	13.5 – 133	48.7	(soil)
<i>Bien Hoa</i>	24	1.19 – 833	797	(sediment)
<i>Can Tho</i>	5	2.04 – 70.4	68.7	(soil)
<i>Tan Son Nhut</i>	5	2.06 – 341	157	(sediment)

A review of international guidelines for soils and sediments suggests that if the concentrations of TCDD recorded at, for example, Da Nang, Phu Cat, and Bien Hoa were found in Europe and North America, remedial action and further investigations would be prescribed. However, in Viet Nam, given economic conditions, there is currently minimal capacity and funding for remediation dioxin contamination. The issue of remediating dioxincontaminated lands/waterbodies has not been addressed in Viet Nam to any large degree. Remediation always raises complex questions, and all commonly accepted remediation methods are expensive. Therefore, international cooperation and international financial assistance are required.

Military bases listed as dioxin hot spots during our investigations were categorized on the basis of dioxin levels recorded at sampling sites distributed near each installation. As noted above, 'primary' sites of contamination were not identified/sampled; therefore, even if a base was categorized as not significantly contaminated, the base may still be 'hot' if the exact location of Ranch Hand activities were identified and sampled. Exclusion from the 'hot' category does not necessarily mean a former US military base in Viet Nam is not contaminated, but is indicative that based on limited sampling; no significant contamination was identified (i.e., significant, in this study, is defined as ≥ 190 pg/g TCDD.).

For bases identified as hot spots (Bien Hoa, Da Nang, and Phu Cat), simple methods could be applied within each area to better understand the level and extent of dioxin contamination and protect local populations. Mitigation measures are required to eliminate potential exposure of populations living

immediately near or downstream of contaminated bases. Protection of human populations living near hot spots should be the first priority. Given that sites are so specific and presumed limited to sluices or streams running from the 'primary hot spot,' communitybased programs should be implemented in those specific areas. This can begin immediately with familyfamily awareness raising by local health officials in hot spot areas to help people reduce their exposure to dioxins.

Following more than twelve years of research, the authors conclude that there does remain a dioxin problem in Viet Nam in key 'hot spots.' However, we suspect levels of dioxin found in soils of most areas of Viet Nam are below international guidelines and that the majority of land in Viet Nam is not contaminated by dioxin. The authors feel that the dioxin problem in Viet Nam is manageable. Current levels of dioxin contamination in soils in most of southern Viet Nam do not generally pose a human health concern. This is good news for residents in areas sprayed during the war and for the economic development of Viet Nam. However, some former US bases and specific runoff areas in their vicinity do remain a serious problem requiring international cooperation and international financial assistance.

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References

1. Dwernychuk LW, Cau HD, Hatfield CT, Boivin TG, Hung TM, Dung PT, Thai ND. *Chemosphere* 2002; 47:117.
2. Dwernychuk LW. *Chemosphere* 2005; 60:998.
3. Cau HD, Dai LC, Hanh LH, Thuy LB, Quynh HY, Hein NM, Thom LH, Schechter A, Constable J. *Herbicides in War - The Long-term Effects on Man and Nature. 2nd International Symposium* 1994:25.
4. Dai LC, Minh DQ, Quynh HT, Thom LH, Thuy LB. *Herbicides in War – The Long-term Effects on Man and Nature. 2nd International Symposium* 1994:5.
5. Dai LC, Hanh LH, Giay T, Hue ND, Thuy LB. *Herbicides in War – The Long-term Effects on Man and Nature. 2nd International Symposium* 1994:40.
6. Dai LC, Thuy LB, Minh DQ, Quynh HT, Thom LH. *Organohalogen Compounds* 1995; 26:161.
7. Schechter A(Ed). *Dioxins and health* 1994:710.
8. Schechter A, Dai LC, Papke O, Prange J, Constable JD, Matsuda M, Thao VD, Piskac AL. *J Occup Environ Med* 2001; 43: 435.
9. Schechter A, Pavuk M, Constable J, Dai LC, Papke O. *J Occup Environ Med* 2002;44:218.
10. IOM (Institute of Medicine). *Veterans and Agent Orange - Update 2000* 2001:604.
11. Westing AH. *Herbicides In War, The Long-term Ecological and Human Consequence.* 1984:3.

12. IOM (Institute of Medicine). *Veterans and Agent Orange - Health effects of herbicides used in Viet Nam*. National Academy Press, Washington, D.C. 1994:812.
13. Stellman JM, Stellman SD, Christian R, Weber T, Tomassallo C. *Nature* 2003; 422:681.
14. US Army documents (declassified). *The US Army Center of Military History, Fort Lesley J. McNair DC*, 20319-5048, USA 1969.
15. US Army documents (declassified). *The US Army Center of Military History, Fort Lesley J. McNair DC*, 20319-5048, USA 1970.
16. Cecil PF. *Herbicide Warfare: the RANCH HAND Project in Viet Nam* 1986:290.
17. NATO (North Atlantic Treaty Organization). *Committee on the Challenges of Modern Society* 1988; 176:26.
18. Van den Berg M, Birnbaum L, Bosveld BTC, Brunström B, Cook P, Feeley M, Giesy JP, Hanberg A, Hasegawa R, Kennedy SW, Kubiak T, Larsen JC, van Leeuwen FXR, Liem AKD, Nolt C, Peterson RE, Poellinger L, Safe S, Schrenk D, Tillitt D, Tysklind M, Younes M, Waern F, Zacharewski T. *Environmental Health Perspective* 1998; 106(12):775.