AN UPDATE ON AGENT ORANGE: VIETNAMESE AND US COLLABORATION

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INTRODUCTION AND RESULTS:
This paper updates our ongoing and primarily university based work in Vietnam which began in 1969 and describes major findings and major changes in US Vietnam Agent Orange work at the present time including new Vietnam Agent Orange/dioxin remediation approaches under evaluation now in Vietnam.

1962-1971:
The US and South Vietnam military sprayed Agent Orange phenoxyherbicides contaminated with dioxins over certain areas of the south of Vietnam for purposes of defoliation to destroy forests where enemy troops could hide and food could be grown for these enemy troops from 1962-1971. Most Agent Orange, perhaps 85 %, is believed to have been sprayed from fixed wing aircraft in the so called Ranch Hand project. Some was also sprayed from backpacks, helicopters and navy vessels. The generally accepted estimate of average TCDD content in Agent Orange is approximately 3 ppm[6]. Samples of human milk and of fish were collected by one of us (JDC) in 1970 from heavily sprayed areas of Vietnam. Those analyses found 2,3,7,8-TCDD or dioxin from Agent Orange in some human milk samples at the highest levels ever measured in human milk, up to approximately 1,850 parts per trillion (PPT) in the lipid portion of milk. Table 1 details measured TCDD levels in human milk measured in both northern and southern Vietnam in 1970 as well as the United States in the 1980's. Table 2 describes the levels of TCDD measured in food in southern Vietnam in 1970 and supermarket samples collected in the 1990s in the United States. By way of comparison, human milk usually measures 1-5 PPT TCDD, and in fish less than 0.1 pg/g (PPT) whole or wet weight[1,3]. Soil levels of TCDD worldwide are usually below 1-10 ppt[3], but up to 1,000,000 ppt was reported by us from one soil sample in the Bien Hoa area[5].

Table 1. 2,3,7,8 TCDD levels in human milk collected in Vietnam and the US

Sample Location	n	Year	Level (ppt, lipid)
Dong Nai River Village	1	1970	1,832
Dong Nai River Village	1	1970	1,465
Can Gio Village	1	1970	732
Sai Gon River Village	1	1970	257
Boston, MA, USA	1	1970	ND (LD = 29)
Binghamton, NY, USA and Los Angeles, CA, USA	42 (mean)	1980's	3.3
Hanoi	28 (mean)	1980's	2.2
Ho Chi Minh City	38 (mean)	1980's	7.1

Refs. 16, 20.

Table 2. 2,3,7,8 TCDD levels in Vietnamese fish, crustaceans, and U.S. imported Vietnamese food

Food	Year Collected	Location Collected	TCDD Level, ppt total wet body weight
Prawn	1970	Can Gio Village (seacoast)	14
Catfish	1970	Dong Nai River (interior)	1020
Supermarket Samples	1990's	Dallas, TX	<0.1
Supermarket Samples	1990's	California	<0.1

Refs. 1, 2

1982-2008:
Many exposure assessment and epidemiology studies between 1982 and 2008 were conducted by Vietnamese scientists such as Le Cao Dai, Hong Dinh Cau, Nguyen Ngoc Thi Phuong, Hoang Trong Quynh and other colleagues from various hospitals and the Central Hanoi based "10-80 Committee to Study the Consequences of Herbicides used in Wartime" and US, German, Canadian, French, Japanese and Russian scientists[7,8].The Health Canada human tissue dioxin analyses performed by Dr. John Jake Ryan from samples collected by two of us (AS and JDC) showed elevation in TCDD in some human and some biological specimens, as did analyses conducted by Olaf Paepke at ERGO Laboratory in Hamburg Germany[3,5]. Several international conferences were held, one in Ho Chi Minh City (1983), chaired by Prof. Hoang Dinh Cau and a later one in Hanoi (1994); two of us (JD and AS) attended and participated. A third international workshop was held under the auspices of the National Institute of Environmental Sciences and the Vietnamese government in Vietnam.

Exposure studies were also conducted by the Canadian Hatfield environmental group which later also documented TCDD contamination in soil, sediment, food and humans in certain areas in Vietnam. Epidemiology studies carried out with Prof. Nguyen Ngoc Thi Phuong of Tu Du Obstetrics Hospital in Ho Chi Minh City and French scientists Dennis Bard and Sylvaine Cordier of Paris failed to find an association between possible dioxin exposure and choriocarcinoma and hydatidiform mole, which had been previously been reported in Vietnamese pilot studies[7,8,9]. A WHO cancer study with adipose tissue specimens from the south of Vietnam from cancer patients failed to demonstrate elevated TCDD in any of the 25 samples analyzed for dioxins[10]. Some Vietnamese studies suggested an increase in congenital malformations when a parent was exposed to TCDD[7,8], but to date, the IOM/NAS reports suggest only spina bifida and anencephaly may be related to dioxin exposure in the mother, based on human and toxicological studies[11]. One NIEHS NIH study began to investigate the possible relationship between dioxin exposure in exposed Vietnamese women and congenital malformations. The principal investigator, Dr. David Carpenter of the State University of New York School of Public Health in Albany, NY, was unable to continue this study to the satisfaction of the Vietnamese government and the NIH, so it was aborted after approximately 3 months[12].

1998-2000s
Studies by Prof. Le Cao Dai, Arnold Schecter, John Constable and Olaf Paepke, later followed by research primarily with Prof Hoang Trong Quynh after the untimely death of Prof. Dai, found very high levels of TCDD, up to over 400 ppt, lipid, in blood from some persons living in and around Bien Hoa, which had been used as an airbase during wartime and where Agent Orange was stored. Table 3 details elevated TCDD levels measured in southern and central Vietnamese pooled blood samples compared to northern Vietnamese samples.

Table 3. 2,3,7,8 TCDD and Dioxin Toxic Equivalents (Lipid basis, ppt) in Vietnamese Pooled Blood collected 1991 through 1992

Region	n	Range of TCDD	Range of TEQ
Northern Vietnam	168	1.2-2.9	12.0-18.0
Central Vietnam	490	2.9-19	23-118
Southern Vietnam	2062	1.0-33	8.7-105

Ref. 3

Fish, ducks and other animals used for food also had quite high levels of TCDD from Agent Orange, which could be determined because none of the other dioxins found in people, but not in Agent Orange, were elevated[13]. It was apparent that consumption of newly contaminated food of animal origin was contributing to current TCDD Orange contamination of people. Sediment and soil was elevated and we believe fish, ducks and other animals used for food had an intake and bioconcentration of dioxin from sediment and soil which then found its way into persons consuming these foods. The Hatfield Canadian consulting group also found elevated TCDD in humans, food, and environmental samples in and around an airfield in the Central Highlands[14]. Later research found elevated TCDD in soil in and around parts of the Da Nang Airbase. These airfields were used to store Agent Orange during the war[15]. Where elevated TCDD was found in high concentration in soil in or around airbases formerly associated with Agent Orange, these sites became commonly referred to as (dioxin) "hot spots". Table 4 describes the elevated TCDD soil concentrations found in three dioxin "hotspots". However, areas other than "hotspots" were noted where there was elevated TCDD in humans and in wildlife[3,16].

Table 4. Dioxin concentrations (>90% TEQ 2,3,7,8-TCDD) in soil and lake sediment of dioxin hotspots of three airports

Location	n	Range (I-TEQ,pg/g dry wt.)	Estimation for dioxin-cleanup area
Da Nang	63	4.3 - 200,338	~104,000m^2
Bien Hoa	54	nd - 409,818	~30,000m^2
Phu Cat	12	0.1-49,462	>2,000m^2

Ref. 15

2000-2008

Focus has now shifted to a large extent on remediation of dioxin hot spots or areas with especially high dioxin levels such as airbases. The Ford Foundation, under the direction of Charles Bailey and his colleagues committed or funded over 1 million US dollars for this work and is trying to encourage other foundations to contribute[17]. The US government, with the impetus coming from Senator Leahy, has provided $3,000,000 to study methods of remediation, some of which are described in Table 5. The State Department is serving as a focus for this effort[18].

Table 5. Long Term Remediation Technologies for Dioxin Contamination

Technology	Status
Thermal	Proven Effective, Very Expensive
Solidification/Stabilization	Proven, less expensive
Physical/Chemical	Piloted with some success
Bioremediation	Unproven with pilots underway
Containment	Proven Effective, Inexpensive

Ref. 19

Methods of remediation can vary from fencing off contaminated areas, forbidding food to be eaten from contaminated areas, taking soil and sediment to a toxic waste landfill, high temperature incineration (a proven but method), and biological degradation with microorganisms (which works under laboratory conditions but not in the field). With finite money, how to best spend it to improve the health of those Vietnamese who could be affected by Agent Orange is a difficult problem. Some have suggested some funds be used for better nutrition, immunizations, housing and education in addition to keeping dioxin from people.

2007-2008 (US Veteran Health Studies)

Ironically, a major American study, the Air Force Veterans Health Study or the Ranch Hand Study, which lasted over 20 years and spent more than $100,000,000 million dollars, has been shut down by the Air Force and given, in theory, to the Institute of Medicine to continue research on health effects of Agent Orange. However, despite U.S. government funding of $3,000,000 for Vietnam Agent Orange remediation work, no funds have been allocated for continuation of this study, presumably to be conducted by the IOM with university researchers.

DISCUSSION AND RECOMMENDATIONS:

It seems to us that the most urgent public health issue with respect to dioxin from Agent Orange in Vietnam is to prevent Vietnamese from further intake of the dioxin, TCDD, of Agent Orange. This will require mapping out where the dioxin now is and where elevated levels are currently found in Vietnamese, especially sensitive populations such as pregnant women, children and those with various diseases. Simultaneous mapping of airplane, backpack, helicopter and navy spraying of TCDD from Agent Orange in environmental and human samples by measurement of blood, soil, sediment, wildlife and food by a highly qualified dioxin laboratory using high resolution gas chromatography-mass spectroscopy, the only validated or “gold standard” for dioxin measurements, is needed as a first step. Where spraying occurred decades ago is not necessarily where TCDD can be found today; wind, rain and floods may have moved the dioxin from where it was originally sprayed. The phenoxyherbicides degrade in days and do not persist as do dioxins.

Contaminated areas should be fenced off and fish, ducks, wildlife and other food from these areas should not be consumed. Substitute food safe for human consumption should be provided. Since dioxins have an effect on the

immune system, are carcinogens, disrupt endocrine, reproductive, developmental, the central and peripheral nervous system especially with *in utero* exposure, attention to health of those potentially exposed is indicated. The effects of bombs, bullets, other chemicals, malnutrition, and lack of education due at least in part to war, need to be addressed.

It is neither easy nor inexpensive to tease out causes of illnesses due to dioxins or other conditions, so it may be far less expensive, once mapping out of dioxins by blood levels in various areas has been accomplished, to focus on treatment and prevention of disease rather than conduct a dioxin health research project, although this research could have considerable public health and scientific merit. However, sufficient money does not appear to be available to do all that is desirable for the health of sick Vietnamese or for dioxin exposed persons who may become ill. We recommend remediation go hand in hand with assistance for those in need regardless of the cause of illness, and, funding permitting, health studies also.

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